# POWER PLANT ENGINEERING

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## From This Point of View

YOU WOULD scarcely recognize the land of fair women, fast horses and good whiskey. Yes, it is none other than the great state of Kentucky at which you are looking from a point 12,000 ft. in the air. No, that is not a fire in the woods. It's a cloud somewhere in that 12,000 ft. of space between you and "terra cotta."

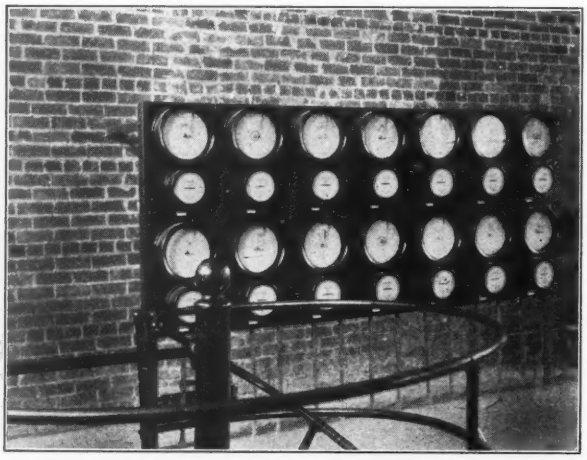
You don't often get such a splendid view of the silver lining of a cloud, although you probably have heard that every cloud has one.

This photograph was not intended to be the basis for a jig-saw puzzle or a cubist painting. It was made by the Bowman Park Aero Co. as part of an aerial survey for use in transmission line design. But it certainly shows the difference caused by a new viewpoint. We don't believe many Kentuckians would recognize their beloved Blue-grass country from this point.

Speaking of new viewpoints, P. B. Place, on page 1102 of this issue, adopts an unusual one from which to discuss carbon losses in boiler refuse. A study of the charts and calculations he presents will repay every power plant engineer.

Perhaps, however, the above illustration would be more appropriate for the article by Leo. T. Parker on page 1123, entitled, "When is an engineer liable on contracts signed for his employer," for does it not portray the view a judge or juryman gets as a case opens up in court? Here we have the smoke screen set up by the attorneys, the two lines of argument leading the jurymen toward the solution but eventually taking them clear out of the picture, the evidence of witnesses is represented in true cubist's style—angular, distorted, light and heavy. If you would avoid this sickening and expensive view, Mr. Parker's formula will be welcome.

# Modern and Efficient Power Plant



## *Supplies*

## STEAM *and* POWER

## *for the*

## HARRIMAN CO.

## *Paper Mill*

Three 500-hp. boilers and 1750 kw. of generating capacity furnish steam and electric power to new mill on the Emery River at Harriman, Tenn.

REMARKABLE ADVANCES have been made in paper mill power plant design and operation during the last few years and these developments are reflected in the new Harriman, Tennessee, plant of the Harriman Co., a subsidiary of The Mead Pulp & Paper Co. The plant, designed and constructed by the Management Engineering & Development Co. of Dayton, Ohio, manufactures chestnut tanning extract and chestnut corrugating paper board.

Chestnut timber, chopped and shredded, is leached with water to remove the tannic acid. This weak solution of tannic acid is evaporated in quadruple effect evaporators to the consistency of syrup before going to the drum dryer when the water is entirely removed and the tannic acid removed in powder form to be put in bags ready for shipment. Chips after leaving the leach house are made into paper passing through the digesters, rod mills and Jordans on the way to the 75-t., 150-in. Black & Clawson paper machine.

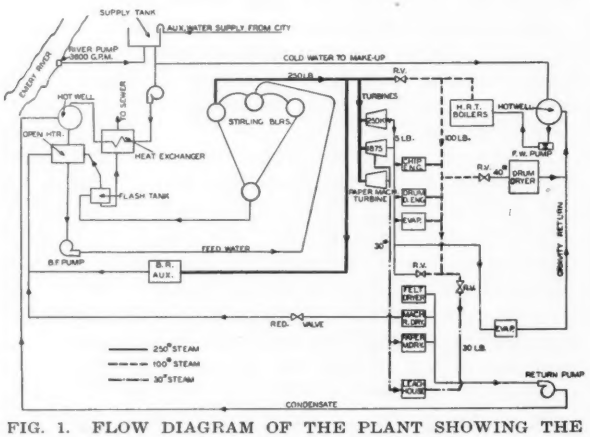



FIG. 1. FLOW DIAGRAM OF THE PLANT SHOWING THE 250, 100, 30 AND 5 LB. SYSTEMS

Electric power is furnished by a 1875-kv-a., 550-v., 3-phase, 60-cycle General Electric turbine unit arranged for 5-lb. back pressure and 30-lb. extraction and a 250-kw. and 5-lb. back pressure unit which is used when the paper machine is not operating. Steam is used at six different pressures, 250, 100, 40, 30, 5 and 2 lb. gage. For the high pressure or 250-lb. system, steam is supplied by three 500-hp. Stirling boilers fired by Frederick motor driven underfeed stokers with both forced and induced draft. This steam is used for the turbines driving the generators and auxiliaries as well as on the 300-hp. 2900-r.p.m. Terry Type C-1 geared turbine driving the paper machine.

### Wood Waste Burned Only When Paper Machine Is Not Operating

Before being taken over by the Harriman Co., the plant manufactured only tannic acid and the chips after leaching were burned under four 100-hp. h.r.t. boilers which supplied steam at 100-lb. gage for the chipper engines, evaporators, dryer engine and through a reducing valve, 40-lb. steam for the drum dryer. Since the plant has been rebuilt and the paper machine added the h.r.t. boilers are operated only when there is an excess of chips, that is during periods that the paper machine is down. What wood waste is available is still burned under the old boilers and the steam used in the 100-lb. system, the demands beyond this being made up from the 250-lb. system through a reducing valve.

Steam for the 30-lb. system, which includes the paper machine dryers and leach house, is supplied from three sources: extraction from the 1500-kw. turbine; exhaust from the paper machine turbine or through a reducing

valve from the 100-lb. system. The last supply is used only when the paper machine is down.

Exhaust of the turbines and engines supplies the low pressure or 5-lb. system with steam for heating, felt dryer and evaporator, any deficiency being made up from the 100-lb. system through a reducing valve. This system also supplies some steam to the open feedwater heater through a reducing valve which lowers the pressure to 2 lb. gage.

### Continuous Blowdown System Used

Makeup for the boiler system is taken from an elevated supply tank which is kept full either by the 3600-g.p.m. river pump which supplies general service to the entire plant or by an auxiliary water supply from the city. From this supply tank the water is fed by a Goulds, 3-in. 250 g.p.m., 60-ft. head, single-stage, motor driven, centrifugal pump through the blowoff heat exchanger to a Cochrane hotwell equipped with a Fisher float controlled valve. This surge tank or hotwell also receives the return from the paper machines and dryers.

From the surge tank, the feedwater flows by gravity to the Cochrane open metering type heater and then to the boiler feed pumps. Two 4-in. 6-stage, 1750-r.p.m., 200-g.p.m., 650-ft. head Goulds centrifugal boiler feed pumps are installed, one driven by a General Electric 50-hp. motor, the other by a Terry 55-hp. steam turbine. Steam for the open heater is supplied from the steam driven boiler house auxiliaries, from the flash tank of the Cochrane blowdown system or from the 5-lb. system through a reducing valve. A Cochrane 3½ lb. back pressure valve prevents the pressure from exceeding this value. Cold makeup for the h.r.t. boilers goes to the hotwell with the gravity returns as shown in Fig. 1.

The Sturtevant induced draft fan which serves all three boilers is driven by a Terry 135-hp., 2245-r.p.m. turbine through gears at 454 r.p.m. One forced draft fan is supplied for each boiler, each fan being driven by a General Electric 30-hp., 550-v. motor.

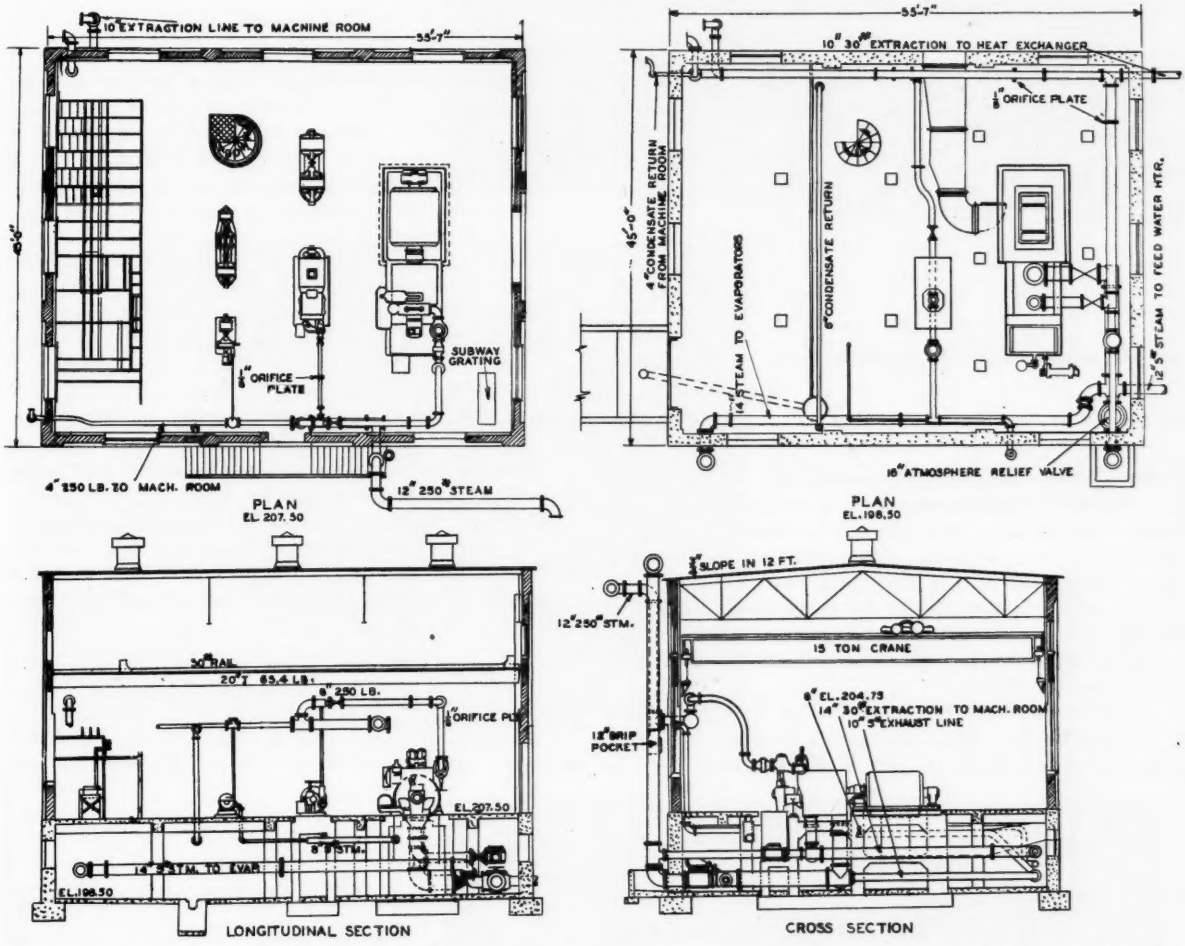



FIG. 2. TWO GENERATING UNITS, STEAM AND MOTOR DRIVEN EXCITERS AND A MOTOR GENERATOR SET ARE INSTALLED IN THE TURBINE ROOM

Coal, received in railroad cars, dumped into a track hopper is fed by a Jeffrey reciprocating feeder to a single roll crusher and then by a belt feeder to the elevator which delivers it through a screw conveyor to the 150-t. bunker from which it is spouted by gravity to the stoker hoppers. The capacity of the coal handling equipment is 40-t. per hr. The feeders and crusher are driven by a 25-hp., 550-v. motor, the elevator by a 10-hp., 550-v. motor and the screw conveyor by a similar 10-hp. motor.

In the turbine room the 1875-kv-a. bleeder turbine is designed to carry the electric load when the paper machine is in operation. The electric load on Sundays or when the paper machine is down is carried by the

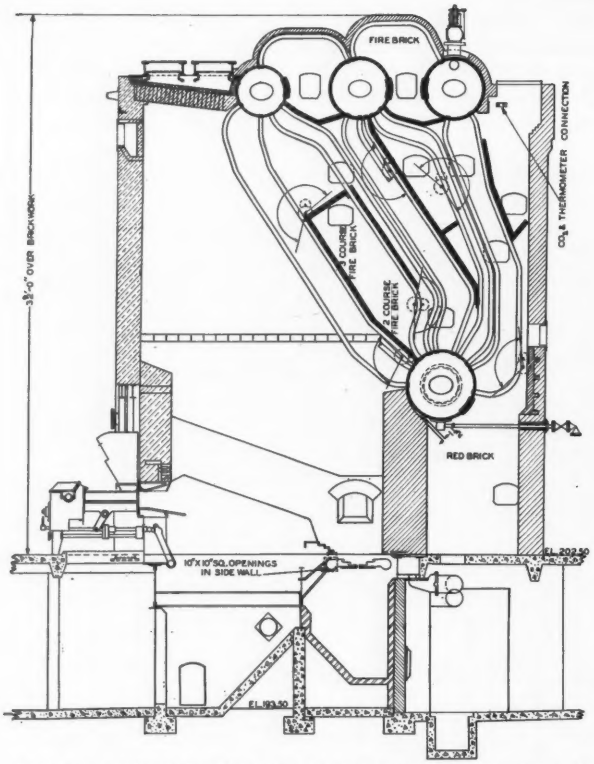



FIG. 3. STIRLING BOILERS ARE FIRED BY FREDERICK UNDERFEED STOKERS

250-kw. turbine unit which exhausts at 5 lb. In addition to these two machines, there is a General Electric 15-kw. single-stage, back pressure turbine driving a 125-v. d.c. exciter; a 60-hp., 550-v. induction motor driving a 55-kw., 125-v., d.c. compound wound exciter and a 3-kw., 125-v., d.c. generator for relay operation and a 150-hp., 550-v. induction motor driving a 100-kw. compound wound 250-v. d.c. generator which supplies direct current for the plant.

These machines are all shown in Fig. 6 with the 250-v. motor generator set at the extreme right. Both exciters are shown again in Fig. 8 together with the 17-

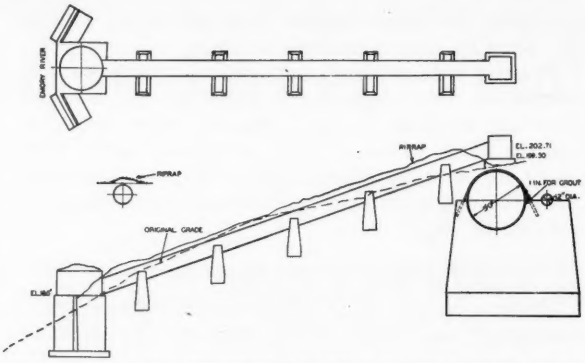



FIG. 5. AS A PROTECTION AGAINST FLOODS THE RIVER PUMP IS INSTALLED IN A WATERPROOF HOUSING

panel black slate switchboard and a portion of the instrument board which will eventually have 17 indicating and recording flow meters. The turbine room is ventilated by two motor driven exhaust fans.

One of the interesting features of the plant is the provision made for protecting the river pump from high water. This pump, a Goulds 3600-g.p.m., 125-ft. head centrifugal, driven by a General Electric, 150-hp., 550-v. motor, is installed, as shown in Fig. 5. The waterproof steel housing, set upon a concrete structure which incorporates the intake racks and protecting wing walls, is provided with a 50-in. dia. steel tunnel leading up to elevation 199.5 or about 35 ft. above the pump. This allows a river rise of about 50 ft. above low water. In extreme high water or floods, the watertight hatch at the entrance to the tunnel can be closed and the pump operated in the totally enclosed and submerged chamber.

This pump supplies most of the general service water for the plant although some of this water is at present furnished from deep wells pumped by air lifts, two 8 and 11 by 14-in. Sullivan angle compound compressors belted to General Electric 150-hp., 690 r.p.m., 550-v. motors being used for this service.

### All Steam and Water Is Metered

An examination of Fig. 1 will show the provision made for taking care of all the process requirements

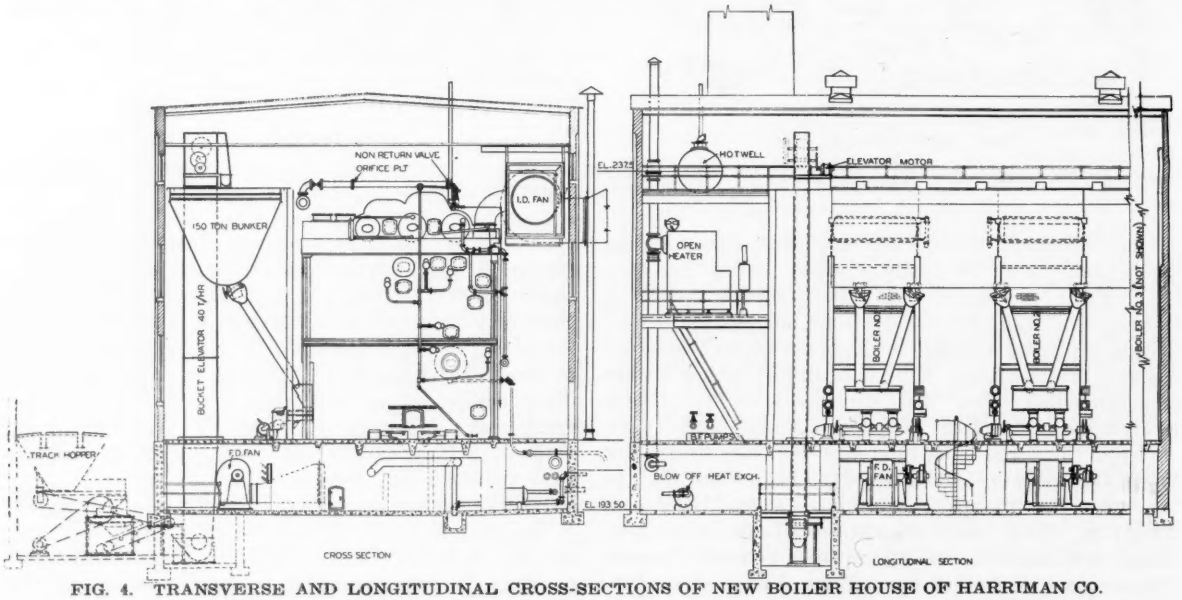



FIG. 4. TRANSVERSE AND LONGITUDINAL CROSS-SECTIONS OF NEW BOILER HOUSE OF HARRIMAN CO.

FIG. 6. THE TURBINE IN THE FOREGROUND IS A 1500-KW. UNIT BLED AT 30 LB. GAGE AND EXHAUSTING AGAINST 5 LB. BACK PRESSURE

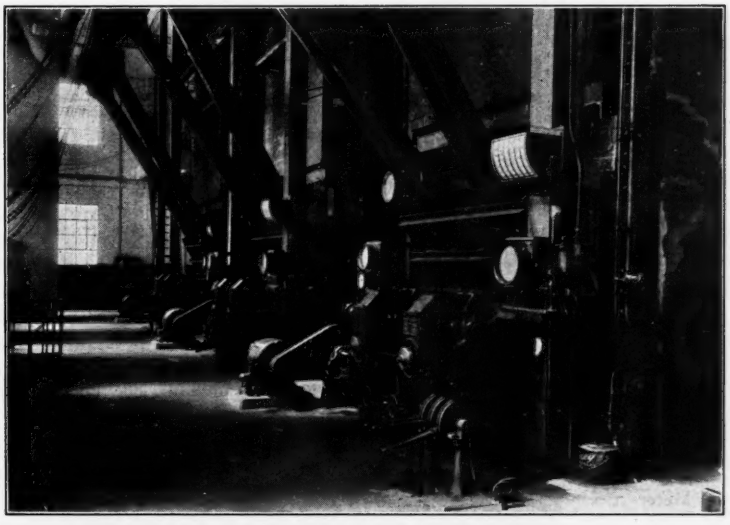


FIG. 7. STEAM AT 250 LB. GAGE IS FURNISHED BY STIRLING BOILERS FIRED BY MOTOR DRIVEN FREDERICK STOKERS

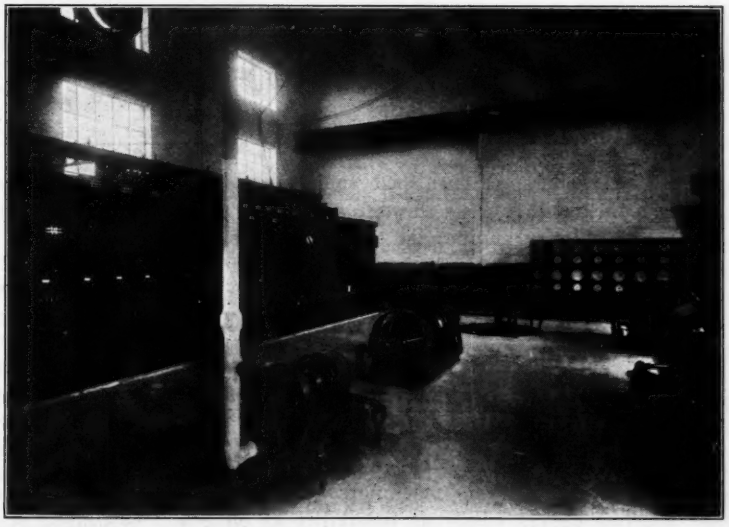


FIG. 8. ON SUNDAYS AND WHEN THE PAPER MACHINE IS DOWN, THE PLANT LOAD IS CARRIED BY THE 250-KW. TURBINE AT THE RIGHT

from the 250-lb. system in case there are no chips to burn under the 100-lb. boilers. Under normal conditions with the paper machine in operation, the 1500-kw. turbine, the boiler room auxiliaries and the paper machine turbine will take 250-lb. steam. The latter exhausts at 30 lb. and the main unit is bled at 30 lb. to supply the paper machine dryers and leach house with 30-lb. steam. If the paper machine is not in operation, the leach house is supplied with 30-lb. steam through a reducing valve from the 100-lb. system.

The 100-lb. system, carried partially by the wood burning h.r.t. boilers, is furnished sufficient makeup steam from the 250-lb. system through a reducing valve to carry the chipper engine, the drum dryer engine evaporator and, through a reducing valve to 40 lb., the drum dryers. The engines, evaporator and turbine exhaust to the 5-lb. system which carries the felt dryer, machine room heater and evaporator and in addition through a reducing valve, sufficient steam to maintain 2-lb. pressure in the open feedwater heater.

Condensate from the drum dryers and evaporators flows by gravity to the h.r.t. boiler hotwell while condensate from the felt dryers, machine room heaters and paper machine dryers where no possibility of oil contamination exists is returned to the hotwell of the 250-lb. boiler house by a return pump in the paper machine room basement.

When completed, an installation of 17 Republic indicating and recording flow meters will make possible a complete steam balance each day. On the 250-lb. system, steam to the boiler room auxiliaries, 1500-kw. turbine, 250-kw. turbine, paper machine turbine and steam through the 100-lb. reducing valve is measured, as is the 30-lb. steam extracted from the turbine and the steam used by the paper machine dryers and leach house; the 100-lb. system steam to the engines and evaporators and the 5-lb. system steam to the evaporators, machine room heater and makeup to the feedwater system. Boiler feedwater to the pumps is measured by a V-notch meter.

Although simple, the plant is designed for efficient and reliable operation entirely isolated from other power sources. Complicated as it was by the requirements of the old 100-lb. equipment, the necessity for providing an outlet for chips when the paper machine was down or using the surplus above the paper machine demands, and the provision for balancing the steam and electric load by steam and motor driven auxiliaries without condensers, the design has been admirably handled and can be studied to advantage by all industrial engineers faced with the problem of process steam and power supply.

## Principal Equipment in Harriman Co. Power Plant

### BOILER ROOM

3 Babcock & Wilcox Co., Stirling type XXII, 500-hp., 250-lb., gage boilers with 392, 3¼-in. tubes, two 36 and one 42-in. dia. steam drums and a 48-in. dia. mud drum.

3 Combustion Engineering Corp., 5-retort Frederick underfeed stokers driven by General Electric 5-hp., 230-v., d.c. motors with a speed variation of from 400 to 1600 r.p.m.

1 B. F. Sturtevant Co. 454-r.p.m. induced draft fan driven by a Terry type G 135-hp. 250-lb. steam pressure, 10-lb. back pressure, 2245 r.p.m. turbine through Terry gears.

3 B. F. Sturtevant Co. type T. V. size 75 forced draft fans driven by General Electric 30-hp. 550-v. motors.

2 Goulds Pumps, Inc. 4-in., 6-stage, 200-g.p.m., 650-ft. head, 1750 r.p.m. boiler feed pumps. One driven by a General Electric 50-hp., 550-v. motor, the other by a Terry type Z2, 55-hp., 225-lb., 5-10 lb. back pressure turbine.

1 Goulds Pumps, Inc., 3-in., single-stage, 250-g.p.m., 60-ft. head centrifugal makeup pump driven by a General Electric 10-hp., 1750-r.p.m., 550-v. motor.

1 Cochrane Corp., 150,000-lb. per hr. open feedwater heater and V-notch meter.

1 Goulds Pumps, Inc. sump pump driven by a General Electric ¼-hp., 1750-r.p.m., 110-v. motor.

Hotwell or surge tank.....Cochrane Corp.
Continuous blowdown system.....Cochrane Corp.
Coal handling equipment, 40-t. per hr...Jeffrey Mfg. Co.
Feedwater regulators (Copes).....Northern Equip. Co.
Soot blowers.....Diamond Power Spec. Corp.
Damper regulators.....Ruggles-Klingemann Mfg. Co.
$CO_2$ meters.....Republic Flow Meters Co.
Draft gages.....Hays Corp.
Boiler check valves.....Elliott Co.
Safety valves.....Crane Co.
Grating and stairs.....Irving Iron Works
Pump governor.....Fisher Governor Co.
Steam gages.....Consolidated Ashcroft Hancock Co.
Blowoff valves.....A. W. Cadman Mfg. Co.

### TURBINE ROOM

1 General Electric Co. 1500-kw., 3600-r.p.m., 3-stage, 225-lb., 5-lb. back pressure, 30-lb. extraction turbine driving an 1875-kv-a., 600-v., 3-phase, 60-cycle, type ATB generator.

1 General Electric Co., 250-kw., 3600-r.p.m., type D53, 2-stage 225-lb., 5-lb. back pressure turbine driving a 250-kw., 600-v., 3-phase, 60-cycle type ATB generator.

1 General Electric Co., 15-kw., 3600-r.p.m., type D52, single stage, 275-lb., 5-lb. back pressure turbine driving a 125-v. d.c. exciter.

1 General Electric Co. motor-driven exciter set consisting of a 60-hp., 1200-r.p.m., 550-v. induction motor driving a 55-kw., 125-v. compound wound exciter and a 3-kw., 125-v. d.c. generator for relay operation.

1 General Electric Co. motor generator set consisting of a 150-hp., 1200-r.p.m., 550-v., induction motor driving a 100-kw., 250-v., d.c. compound wound generator.

1 General Electric Co., 17-panel black slate switchboard complete with instruments.

1 General Electric Co. 25-kv-a., 550 to 115/230-v. transformers.

1 Exide Battery Co. storage battery.

1 Goulds Pumps, Inc., 40 g.p.m., 20-ft. head, 1750-r.p.m., sump pump driven by a Century ¾ hp., 110-v. motor with Cutler-Hammer float control.

### MISCELLANEOUS

1 Goulds Pumps, Inc. general service pumps, 3600-g.p.m., 135-ft. head, 1750-r.p.m. single-stage centrifugal driven by a General Electric 150-hp., 550-v. motor.

2 Sullivan Machinery Co., 8 and 11 by 14-in. angle compound compressors belted to General Electric 150-hp., 690 r.p.m., 550-v. motors.

Pipe covering.....The Philip Carey Co.
Reducing valves.....A. W. Cash Co., McAlear Mfg. Co.
Traps.....
Armstrong Machine Works, Crane Co., Nason Mfg. Co.
Flow meters.....Republic Flow Meters Co.
Expansion joints.....E. B. Badger & Sons Co.
Valves.....Crane Co.
Pipe.....Crane Co.

# Use and Control of Steam in the Sugar Industry

IN WESTERN BEET SUGAR PLANTS, NEED OF FLUE GAS FOR DRYING AND LARGE AMOUNTS OF STEAM FOR EVAPORATING GIVES RISE TO MANY INTERESTING PROBLEMS. BY J. R. GOODNER

MOST OF THE processes of manufacturing sugar depend, sooner or later, upon one important factor of any power plant—evaporation. To this might be added efficient expansion but, since heat and evaporation play the greater part, expansion (or power) becomes secondary.

Since water is used extensively in the extraction and refining but must eventually be removed, evaporation of this water makes a sugar factory, as a whole, a rather prolonged system of evaporation or boiling. Like the links of a chain, every station or step is dependent, in a way, upon the one preceding or following it.

It is here that the steam balance comes into use, for each "station" is designed and arranged to meet the demand made upon it and, at the same time, to absorb or generate its allotment of heat or energy or both. The following comments on how this is done apply especially to beet sugar plants in the West.

For fuel, in the western part of the country, western lignite, averaging around 10,000 B.t.u., 25 per cent moisture and 7 per cent ash, is generally used. Mine run is delivered throughout the year; because of the excessive slacking, also, because the campaign period is short, the coal is stored below water. As needed, a crane and clamshell delivers it to the crushers, where it is crushed to about "pea" size. It is next elevated and distributed to the bunkers, as in the usual boiler house practice. Here is stored a supply for about two shifts. It might be mentioned that here water is added to the coal provided there is not sufficient surface moisture as desired for firing.

Chain grate stokers are generally favored where coal is used as fuel. Even where gas is available, the boilers are equipped with stokers as standby. Coal burned averages around 33 lb. per sq. ft. of grate surface per hour except where flue gas is used for drying the beet pulp, when this figure reaches 40 lb.

### CONSTANT FLUE GAS VOLUME, SOMETIMES NEEDED FOR DRYING BEET PULP, GOVERNS BOILER OPERATION

Practice has proved that in the latter case, a different method of firing must be maintained. Since the amount of water to be evaporated from the pulp is somewhat of a constant, a similarly constant volume of flue gas available for the drying must also be maintained, temperature considered. This has led to a practice of steady firing and an even damper, regardless of steam demand, the generation of steam being controlled by the introduction of excess air above the fire.

In cases where pulp is dried for stock feed and flue gas is used for that purpose, the usual 240-ft. stack is replaced by forced draft and a lower stack. Flue gas temperatures average 500 deg. F. for natural draft and slightly higher in the case of the driers mentioned above.

Coal drips and ash are removed by water and centrifugal pumps to drain pits. The water used is often the discard from one or more of the extraction processes and from these drainage pits goes to the sewer.

Water-tube boilers have replaced all other types and the later installations seem to favor the V types. Although superheaters and economizers are not always used, the adoption of the steam turbine for main drives has permitted many plants to take advantage of them.

### FEEDWATER MUST BE WATCHED FOR SUGAR

Feedwater ranging from about 195 deg. to 205 deg. F. consists of condensate from such trap discharges and drips as are free from contamination, yet an hourly check for excess sugar in water is taken. The water in the boilers is kept at a pH of 8.0, or as near that as possible. Experience has shown that the higher the pH value the more "wild" the water, apparently more so in vertical tubular boilers. Sugar, the most common impurity in the water, seems to decompose to form acids at boiler temperatures; it becomes necessary, therefore, to introduce compounds to overcome the lowering of the pH value by these impurities. It will be noted here that the amount of solids in water is not considered.

Steam reciprocating or centrifugal pumps maintain the feedwater pressure, though at some plants an auxiliary pump delivers direct from a coil drip pig to the feedwater header. By so doing, the water is pumped at a high temperature since the system is under pressure.

### PROCESSES REQUIRE SEVERAL STEAM PRESSURES

About two-thirds of the steam generated expands in power machinery, exhausting to systems that supply the process with steam. Most plants have the following steam systems, by their sugar factory names: live steam at 140 lb. pressure; boiling, at 125 to 140 lb., reduced by automatic valves to 85 lb.; high exhaust at 55 lb. and low exhaust at 15 lb. Boiling steam has been eliminated to some extent by the use of large surface boiling pans heated from vapors of evaporation from earlier stages of the process or exhaust.

High exhaust is eliminated through the use of calorisators for heating diffusion juice instead of injecting steam as practiced in some plants.

These calorisators are heated by vapor from the first or second body of evaporators instead of by low exhaust. This has the advantage of gaining this heat from the low exhaust after it has evaporated one or two pounds of water per pound of steam, depending upon the vapors used. It is by use of evaporators that the evaporation usually runs above 25 lb. of water per pound of 9500-B.t.u. coal.

Where the four systems are used, the following systems of regulating valves control the operations: live to boiling when live is plentiful; boiling to pan coils at 80 lb.; boiling (or live) to high exhaust when high exhaust is scarce; high exhaust to low exhaust when there is excess of high exhaust or scarcity of low exhaust; and finally, low exhaust to atmosphere when there is excess of low exhaust.

Power generating units do not supply sufficient ex-

haust for the processes. Through control of the live steam to the high exhaust and thence to low exhaust through the regulators, the necessary steam can be supplied to the evaporators, the greatest consumer of low exhaust.

Here is really the only control there is on the whole steam system outside the boiler house, except the amount of boiling steam to the pans, which is manually controlled at the pans and which is independent of the exhausts.

Releasing of exhaust to atmosphere, of course, would relieve the pressure at the evaporators but at a loss, especially if the live steam were permitted to maintain or attempt to maintain the desired pressure on high exhaust.

### Details of Evaporation of Water from Beets

Water introduced for the extraction of the sugar from the beets must be removed. The weight of this water is nearly 125 per cent of the weight of the beet sliced. Later on in the process, water for washing the sugar from the filtrate used for purification must be evaporated. One per cent of water here means over 12 lb. of coal per ton of beets sliced.

For removing the excess water, there are five effects of evaporation and the pans. The first body takes exhaust steam at 15 lb.; the vapors generated from this body supply the second body with from 4 to 8 lb. pressure on the chest, and so on to the fifth with a like decline of pressure and temperature, ending in a pair of condensers and a vacuum pump to remove gases. At this point, a vacuum of over 20 in. of mercury is needed.

Water from the leg lines of the condensers, being heated, is returned to the battery or for fluming beets, or some place where the heat can be used to advantage. Even the surplus vapors find their way to heaters used to raise the temperature of juices on their way to or from some process.

The final process of boiling and crystallization is done under high vacuum and low temperatures, supplied by high-pressure steam, unless the vapor pan is used and, in that case, it is a continuation of the vapors from the evaporators. Final drying of the refined sugar, before it enters the containers for the market, is also done with live steam.

# Determining Carbon Losses in Boiler Refuse

Graphical Determinations of Heat Losses from Unburned Carbon Simplify Heat Balance Calculations. By P. B. Place*

WHEN CALCULATING carbon losses for boiler heat balances, the relation between refuse and ash must be clearly understood. Ash refers to the mineral content of coal and is reported as such in the proximate analysis, usually on an as received basis. Refuse is made up of individual deposits in various parts of the furnace and boiler and each deposit may contain different proportions of ash and carbon. The weight of each deposit should be determined or estimated and expressed as per cent by weight of the total refuse. A sample of each deposit should be sent to the laboratory for analysis for its carbon content, which is reported as per cent by weight of the deposit.

*Test Engineer Combustion Engineering Corp.

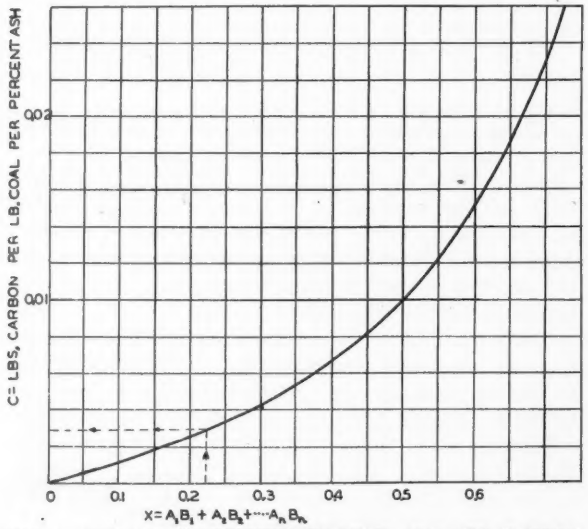



FIG. 1. RELATION BETWEEN REFUSE, ASH AND CARBON LOSSES

Since the total carbon loss in the heat balance is expressed as per cent of the heat value in the coal as fired, it is obviously necessary to take care that all of the individual losses are calculated back to a coal as fired basis before they are compared or the total loss estimated.

Case 1. Assume, for example, a typical pulverized coal fired unit with the following data:

| | |
|---|---|
| Total coal fired over test period | 11,670 lb. |
| Total refuse over test period | 1500 lb. |
| Ash content of the coal | 10 per cent |
| Heat value of the coal | 13,500 B.t.u. |

Table I gives a typical distribution of the refuse and the calculated carbon losses for each deposit and for the total refuse.

These calculations are not difficult when the weight of the total refuse is known. But in many cases, especially with pulverized coal units, this value is difficult to determine and it is then necessary to assume a percentage distribution of the refuse and from the analysis of the separate deposits, calculate the total refuse and the carbon losses. This can be done only by the use of

TABLE I. TYPICAL DISTRIBUTION OF REFUSE AND CARBON LOSSES

| | Ash Pit | Boiler Passes | Stack | Total |
|---|---|---|---|---|
| Lb. refuse in deposit | 300 | 120 | 1080 | 1500 |
| Per cent of total refuse | 20 | 8 | 72 | 100 |
| Per cent carbon in deposit | 5 | 40 | 25 | 22.2 |
| Per cent ash in deposit | 95 | 60 | 75 | 77.8 |
| Lb. carbon lost per deposit | 15 | 48 | 270 | 333 |
| Lb. carbon lost per lb. coal | 0.0013 | 0.0041 | 0.0231 | 0.0285 |
| B.t.u. lost per lb. coal | 19.7 | 59.6 | 335 | 414.3 |
| Per cent of heat in coal lost | 0.15 | 0.44 | 2.48 | 3.07 |

algebra and becomes more complicated, the greater the number of refuse deposits considered.

Case 2. As an illustration, refer to the above example and assume that only the following data are known:

| | |
|---|---|
| Ash content of the coal | 10 per cent |
| Heat value of the coal per lb | 13,500 B.t.u. |
| Carbon in ash pit refuse | 5 per cent |
| Carbon in boiler refuse | 40 per cent |
| Carbon in stack refuse | 25 per cent |

Assume a refuse distribution as follows:

| | |
|---|---|
| Refuse to ash pit | 20 per cent |
| Refuse to boiler passes | 8 per cent |
| Refuse to stack | 72 per cent |

The losses may now be calculated on a basis of one pound of coal, by the use of algebra.

Let $W$ = Lb. of total refuse per lb. of coal.
Then $0.20W$ = Lb. of refuse to ash pit per lb. of coal.
$0.08W$ = Lb. of refuse to boiler per lb. of coal.
$0.72W$ = Lb. of refuse to stack per lb. of coal.
and $0.20W \times (1-0.05)$ = Lb. ash to ash pit per lb. of coal.
$0.80W \times (1-0.40)$ = Lb. ash to boiler per lb. of coal.
$0.72W \times (1-0.25)$ = Lb. ash to stack per lb. of coal.

Since the sum of the last three items equals the total pounds of ash per pound of coal, this sum may be equated to 0.10 and the equation solved for W. Having found the value of W, the carbon losses and heat loss may be readily calculated in the usual manner.

In order to simplify these calculations, the accompanying curves have been prepared. From these curves, the total carbon loss for any coal and for any combination of refuse deposits and their carbon content may be readily derived. The only required data are

a. The proportion by weight of the total refuse, that each deposit is.
b. The carbon content of each deposit as determined by analysis and expressed as a fraction by weight of the individual deposit.
c. The proximate analysis and heat value of the coal on an as fired basis.

Quantities a and b, expressed as fractions, are multiplied for each deposit, and the sum of the products for all of the deposits gives a value X which is the abscissa of a point on the curve, Fig. 1, the ordinate of this point being the pounds of carbon lost per pound of coal fired for each per cent of ash in the coal. In other words, $a_1b_1 = X_1$, $a_2b_2 = X_2$, $a_3b_3 = X_3$, $a_nb_n = X_n$ and $X_1 + X_2 + X_3 \ldots X_n = X$ where the subscripts refer to different refuse deposits such as ash pit, hoppers and stack.

The equation for this curve is

$$100\ c = \frac{RX}{A} = \frac{C}{A} = \frac{1-X}{X}$$

where

R = Lb. of total refuse per lb. of coal.
C = Lb. of carbon lost per lb. of coal.
A = Lb. of ash per lb. of coal.
c = Lb. of carbon lost per lb. of coal for each per cent of ash.

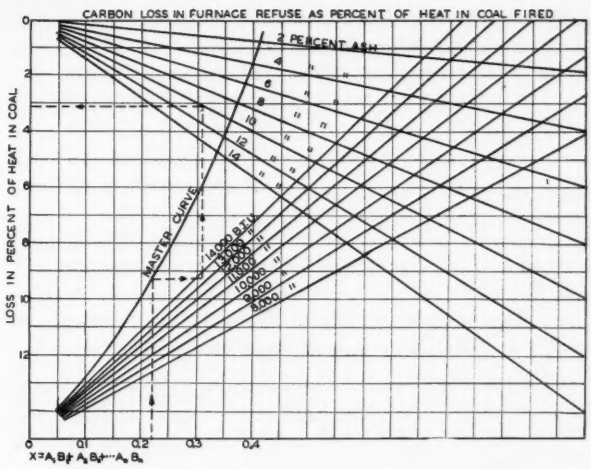



FIG. 2. CHART FOR DETERMINING HEAT LOSSES AS A PERCENTAGE OF THE HEAT OF THE COAL FIRED

X = Proportion of carbon in total refuse expressed as a fraction.
a = Proportion by weight of the total refuse that each deposit is, expressed as a fraction.
b = Proportion of carbon in each deposit, expressed as a fraction.
n = Number of deposits making up the total refuse.

Assuming the data given in Case 2, we have the following solution:

| | a | × | b | = | X |
|---|---|---|---|---|---|
| 1. Ash pit | 0.20 | × | 0.05 | = | 0.010 |
| 2. Passes | 0.08 | × | 0.40 | = | 0.032 |
| 3. Stack | 0.72 | × | 0.25 | = | 0.180 |
| Total | $a_1b_1$ | + | $a_2b_2$ | + | $a_3b_3$ = 0.222 |

The sum of the products for the three deposits is 0.222. For X equal to 0.222, we find from the curve Fig. 1, a value of c equal to 0.0029 lb. of carbon lost per pound of coal for each per cent of ash in the coal. Therefore, if we burn 10,000 lb. of coal an hour and the coal contains 10 per cent ash, we shall lose $0.0029 \times 10{,}000 \times 10 = 290$ lb. carbon per hour. To calculate the heat loss for one pound of coal for heat balance purposes, c must be multiplied by the per cent of ash in the coal and by the ratio of the heat value of carbon to the heat value of the coal. Thus, for the preceding case, the heat loss in per cent of the heat in the coal as fired, would be

$$0.0029 \times 10 \times \frac{14{,}500}{13{,}500} \times 100 = 3.15 \text{ per cent}$$

To eliminate the last calculations, Fig. 2 has been prepared. From this chart, the carbon loss in per cent of the heat in the coal as fired, for coals of any ash or calorific value, and for any distribution of refuse and carbon content of deposits, may be quickly deter-

TABLE II. COMPARISON OF TWO METHODS OF CALCULATING CARBON LOSS

| | Loss from Fig. 2 | Loss by Calculation |
|---|---|---|
| 1. Ash pit | 0.10% | 0.15% |
| 2. Passes | 0.40% | 0.45% |
| 3. Stack | 2.36% | 2.55% |
| Total | 2.86% | 3.15% |

mined. This chart is simply a combination of the master curve developed in Fig. 1 and lines of calorific value and ash content of the coal.

The equations involved are simply:

$$100\ c = \frac{RX}{A}$$

and

$$\frac{c \times 100 \times A \times 14{,}500 \times 100}{H} = L$$

where

H = The heat value of the coal, B.t.u. per lb.
L = The carbon loss in per cent of H.

To solve the example given above, follow the dotted line on Fig. 2. We find that for X equal to 0.222 and for a coal of 13,500 B.t.u. and 10 per cent ash content, the carbon loss in the refuse is 3.15 per cent.

For each deposit, the carbon loss may be approximated by using the product X for each deposit, separately in Fig. 2. The results will be a little low, the correct values being found by multiplying the per cent total carbon loss by the ratio of the product X for the deposit over the sum of the products X for all deposits. A comparison of the two methods for the given example is given in Table II.

In using Fig. 2 for values of X greater than 0.3, the path followed is different from that for values less than 0.3. The following sequence should be followed to avoid confusion: From X up vertically to the master curve; right horizontally to the B.t.u. curve; up or down vertically to the ash curve and finally, left horizontally to the carbon loss.

It should be understood that the foregoing method for finding carbon losses does not conflict in any way with standard test codes. It is simply a means of quickly estimating the individual or combined loss for the various refuse deposits in the unit. When the percentage distribution of the refuse must be assumed, it will be found that the assumed value for the major deposit may be 10 to 15 per cent in error without involving serious error in the final result unless the carbon content of the deposit is particularly high.

In estimating the distribution of the refuse, such factors as: Type of firing, whether stoker or pulverized fuel; character and density of resulting ash; size of coal fired; style of furnace and boiler; rating at which unit is operated and other factors must be considered. It is often possible to weigh or estimate the smaller deposits quite accurately and assume the major deposit by difference.

Table III compares pulverized fuel fired units with stoker fired units.

For any given percentage of carbon in a deposit of refuse, the carbon loss in per cent of the heat in the coal, increases with increasing ash content and with decreasing calorific value. Thus for a deposit containing 30 per cent carbon, the loss for a 14,000 B.t.u. and 4 per cent ash coal is about one-fourth the loss for a 10,000 B.t.u. and 12 per cent ash coal. Table IV shows the variation in heat losses for a constant value of X equal to 0.16 but for different calorific and ash values.

TABLE III. COMPARISON OF DIFFERENT VALUES FOR STOKER AND PULVERIZED COAL FIRING

| | | Pulverized fuel | Stoker fired |
|---|---|---|---|
| a. Per cent refuse to | Ash pit | 10–20 | 80–90 |
| | Passes | 5–10 | 5–10 |
| | Stack | 70–85 | 5–15 |
| b. Per cent carbon in | Ash pit | 0– 5 | 5–25 |
| | Passes | 10–35 | 10–35 |
| | Stack | 5–30 | 5–25 |
| ab. Average product X | Ash pit | 0.0038 | 0.1275 |
| | Passes | 0.0169 | 0.0169 |
| | Stack | 0.1356 | 0.0150 |
| | Total | 0.1563 | 0.1594 |

TABLE IV. COMPARISON OF CARBON LOSSES FOR DIFFERENT COALS

| Ash in coal | Calorific value | Per cent heat loss X = 0.16 |
|---|---|---|
| 6% | 14,000 | 1.2% |
| 12% | 12,000 | 2.8% |
| 18% | 10,000 | 4.8% |

It is apparent that carbon losses should not be too hastily judged from a consideration of the carbon content of the refuse alone. The calorific value of the coal and its ash content are also material factors to be considered. Particular care should be taken when judging losses from a consideration of the carbon content of only one deposit as it may not represent the total refuse in either quality or quantity.

## Power for New International Paper Co. Mill at Dalhousie, N. B.

ACCORDING to a recent announcement, the mill of the International Paper Co. in New Brunswick will be a four-machine mill located at Dalhousie, N. B.; it will make only newsprint. The power plant, which will operate in parallel with the hydroelectric plant at Grand Falls, will contain two turbines. The main turbine is a 7500-kw., back-pressure machine receiving steam at 400 lb. and exhausting it at 135 lb. The emergency turbine is a 900-kw., 125-lb. condensing unit tied in with the main turbine so that, in case of an emergency, the main machine will continue to take the regular amount of process steam and in addition the amount of steam required by the emergency turbine.

Both of the 660-v. generators will operate in parallel with power brought from the hydroelectric plant over a 110-mi., 132-kv., 477,000-cir. mil. steel-core, aluminum cable. An outdoor substation with two 18,000-kv-a. transformer banks will step the voltage down to 6600 v. for use in the mill.

Each paper machine has a complete Harland drive with the direct current supplied by a 1000-hp., 125-lb. turbine operating at a back pressure of 10 lb. gage and driving a 600-kw., 530-v. d.c. generator and a 30-kw., 250-v. exciter through double helical gears. A starting motor-generator set consisting of a 300-hp., 900-r.p.m. synchronous motor, driving a 200-kw., 230-v. d.c. generator has sufficient capacity for starting and crawling the various sections of the machine.

Dryer sections are driven in groups of six drive shafts by 45-hp. motors and will use the dryer felt for a mechanical tie between the groups. The master speed control shaft has a gear drive at two points from the dryer section. The six controlled sections—that is, couch, three presses, calender and reel—have their own individual starting panel with full automatic type operation by levers from the front side of the paper machine.

# Metering in Power Plants*

Classes, Purposes and Uses of Meters and Automatic Boiler Control. By E. G. Bailey

YEARS AGO when coal was plentiful and fuel costs were lower, there was little incentive to develop power plant meters which would aid in using fuel economically. Today, however, there are many instruments which any steam generating plant can afford to install and the value of the information they give justifies the expenditure. The extent to which instruments are applied will vary with the size of the plant but there is no question but that certain meters should be installed in every boiler plant. A definite check should be kept, not only of the amount of steam generated, but also of the amount of steam used at the different points of consumption.

The increase in boiler operating efficiency, as well as the improved economy in steam distribution resulting from the installation of meters, in many cases, postpones or eliminates the necessity for enlarging the power plant. This reduction in overhead should be credited to the metering equipment.

Steam meters have been of great importance in supplying reliable data for maintaining accounting systems. The accounting is far more accurate when the actual quantities of steam and power consumed are known. As a matter of fact, one of the greatest fields for steam meters is on lines leading to the various processes or departments of a manufacturing plant. Experience shows a surprising decrease in steam consumption per unit of output where the steam to each department is metered and charged against the cost of operating that department.

## Classes of Meters

In making an analysis of the subject, all power plant instruments and meters may be divided into three general classes: (1) meters to show conditions such as pressure, temperature and water level, also position of coal level, dampers, valves and the like; (2) meters to show rates of steam, air, water, oil or gas flow, feed of coal or speed of fans or pumps; (3) meters to show relation such as steam flow to air flow and fuel feed or steam to feedwater.

Many of the instruments in a power plant are essential for the safety of the equipment, as well as of operators. Often the indicating type is sufficient, although, in case of an accident or in case of faulty operation, a recorder will serve to locate the cause of the trouble and, from that standpoint, is desirable.

As practically every power plant operation is dependent upon the flow of fluids such as steam, water, air, gas or oil, power plant operators are beginning to appreciate the advantages of indicating or recording stoker speed, pulverized-coal feeder speed, fan speed, pump speed and other rates.

Meters, which show relation as covered by the third classification, are of primary importance as they usually give the complete information necessary for arriving at accurate and definite conclusions. In boiler operation, for instance, it is not sufficient to know simply how much steam a boiler is making, for it is equally important to know how efficiently the steam is being generated and whether or not the correct amount of air is being supplied for complete combustion with a minimum of excess air. This may be determined by a meter to show the steam flow to air flow relation. Such a meter not only indicates and records the rate of steam output but it also guides the operator in controlling the air supply to the boiler so that there is always a definite relation between the amount of air used for combustion and the amount of steam generated from that combustion. As another illustration, the flue gas temperature alone does not indicate the cleanliness of the heating surface and the condition of the baffles, so it is necessary to know the corresponding load being carried by the boiler before we can judge whether or not the gas temperature is excessive. This record should preferably be made on the same chart with the rate of steam flow, so that a comparison between the two records can readily be made.

## Meters for Combustion Conditions and Flue Gas Loss Are Important

In the boiler room, the largest controllable losses are those of heat in the products of combustion, in excess air, in unburned gas and unburned coal, so that the application of a combustion guide to each boiler presents the greatest possibilities for savings in the power plant. Accordingly, meters which serve as efficient and reliable combustion guides should be given first consideration.

To obtain economical combustion, it is desirable to operate with the air supplied to the furnace at the lowest possible amount, without loss due to unburned gas or carbon, or without injury to the furnace.

After installing efficient combustion guides, it is desirable to install temperature recorders for the boiler outlet gases as the information obtained from such recorders gives a check on heat absorption, thus indicating the condition of the boiler tubes and baffles. Temperature recorders should also be applied to economizers and air preheaters, where such equipment is used, to determine the temperatures of water, gas and air for the purpose of checking the heat absorption effectiveness. Such recorders enable the operators to determine when to blow tubes yet not have the cost of tube blowing exceed that due to the loss of heat caused by dirty tubes.

Another loss which can become large in a power plant is from blowing down boilers, particularly in those plants where a continuous system is employed, so that the use of feedwater meters is a point that deserves serious consideration.

*From a paper presented before the Summer School for Engineering Teachers, S. P. E. E. at Purdue University.

In many plants, the results obtained from feedwater meters are used to determine boiler and plant efficiency. This is poor practice, as in such a system the boilers are given credit for the evaporation of water lost in blowing down, as well as water lost due to leakage. Often a boiler, supposedly in good condition, will be leaking enough to lose one or two per cent of the water fed to it and cases have been known where this leakage amounted to 5 or 10 per cent. The steam flow meter should be used for efficiency results, and the feedwater meter for the determination of losses.

Another item of importance is that of fuel fed to the furnace, the type of fuel used determining the method of obtaining the quantity. In the case of oil or gas, a flow meter should be used, whereas if coal is the fuel, coal meters or weighing scales can be installed. If the boiler units are large enough, the recording of stoker, pulverized-coal feeder or pulverizer speeds is well worth while, as the rate and method of supplying fuel have a direct bearing on combustion efficiency.

### Centralized Meters Desirable

Electrically-operated meters are sometimes preferred, as they permit locating the recorders or integrators, or both, at a centralized point. This may be a decided advantage as it provides a means for easily and quickly determining which departments are using the most steam and water. It also indicates the source of any sudden or radical changes in the load on a plant. If the meters are installed solely for the purpose of determining the distribution of costs for an accounting system, the centralized location will be effective in reducing the time involved in taking daily meter readings.

### Control of Air Supply

The importance of excess air in controlling furnace efficiency and operating conditions is well appreciated by most power plant engineers. Two combinations of meters are in common use as combustion guides and for determining the percentage of excess air being used. One consists of a steam flow meter and $CO_2$ recorder, and the other is the boiler meter recording steam flow and air flow.

While the $CO_2$ percentage is important, it does not present the entire story of combustion efficiency. The percentage of $CO_2$ desired with any given fuel depends upon the chemical composition of that fuel and it may vary from as low as 7½ per cent with coke oven gas to as much as 22.8 per cent with blast furnace gas for 20 per cent excess air. The $CO_2$ may vary more than one per cent with different kinds of coal even though the excess air is held constant. It is, therefore, important to analyze the flue gas for more than $CO_2$ in order to determine accurately the percentage of excess air.

Even if the $CO_2$ percentage were a complete indication of combustion conditions, the stratification of gases existing in the boiler setting makes it practically impossible to obtain a sample to analyze for $CO_2$ which will be truly representative of the average $CO_2$ being obtained.

Combination of steam flow and air flow represents a much more workable unit, as the air flow mechanism of such a meter can be adjusted so that, when the ratio of its reading to that of the steam flow meter is unity, the desired amount of air is being supplied for combustion. Such an adjustment will hold true for any one class of fuel as the flow effect produced by these fuels will be the same within a fraction of one per cent.

With this type of meter it is possible to take into consideration, not only operating with the minimum total air, but also such limiting factors as refractory deterioration at high ratings, smoke at low ratings in water-cooled furnaces and other similar factors that could not be readily known from $CO_2$ alone.

In one pulverized coal installation it is necessary to use about 30 per cent excess air at 100 per cent of boiler rating to prevent smoke. As the boiler load increases, the furnace temperature is increased, aiding combustion so that, at 200 per cent of rating, the excess air may be reduced to approximately 14 per cent without excessive smoke or refractory deterioration. As the boiler load increases from this point, the furnace temperature becomes excessive and the refractory between the water-cooling tubes begins to run, so that it is necessary to increase the excess air gradually with increasing load above 200 per cent until approximately 32 per cent excess air is used at 350 per cent of boiler rating.

In another installation consisting of 3060 hp., pulverized coal fired boilers equipped with refractory air-cooled walls, efficient combustion with little smoke may be obtained with 28 per cent excess air at 100 per cent of boiler rating. In this case the air cooling of the furnace walls is insufficient to protect the refractories at high ratings so the excess air is gradually increased with increased load until it reaches approximately 59 per cent at 300 per cent of boiler rating. This is easily accomplished by making a proper adjustment of the air flow mechanism in the boiler meter so that the steam flow and air flow pens will coincide for the proper excess air at the various ratings.

### Automatic Boiler Control Aids Economy

Rate of supply of fuel and air to steam boilers is bound to be more or less variable, calling for frequent adjustments, especially in the case of a fluctuating load. It is, therefore, practically impossible for a fireman in the large boiler plant to watch all of the indicating and recording instruments that show the conditions in the boiler and make the frequent adjustments in fuel feed, induced draft, forced draft and rate of feedwater flow which are necessary to maintain the desired steam pressure, the proper air supply and water level for best results. It has, therefore, been found advisable and in fact necessary to use automatic control to produce in every-day operation and with a minimum of manual effort, the results which would be obtainable under test conditions and with a full complement of instruments.

For an automatic control system the function is to supply fuel and air to the boiler furnaces in accordance with the demand for steam and in the proper proportions to obtain efficient combustion. At first thought such a problem seems simple but, when an analysis is made of the characteristics of the various items to be controlled, it is easy to see that it is quite difficult. It is seldom that the delivery characteristics of the stoker, pulverized-coal feeders, oil or gas valves, dampers and fans that may be used are such that they will coincide at all boiler ratings.

Such a system may utilize compressed air, oil pressure or electricity as the operating medium, the master

control regulating the dampers, forced and induced draft fans and fuel feed by pilot valves or switches so as to insure proper combustion conditions at all loads. The system must be designed to adjust fuel and air controls so that they will take care of characteristics of equipment at various settings and correct for changes in quality and condition of fuel, atmospheric conditions and condition of the fire and boiler setting. And it must maintain steam pressure under all load demands.

### Safety Interlocks Are Necessary

Safety features should be an important part of any control equipment. They should include limits which will prevent overtravel of rheostats, drum controllers, dampers, valves or other mechanisms being controlled. They should also protect against "runaway conditions" in case of failure of the power supply. It should be impossible, for instance, to change the air supply to the minimum or the fuel supply to the maximum without a corresponding change in the other controlled items. Other desirable safety features include interlocks between the fuel and air supply, to prevent further increase in fuel after the maximum air delivery position has been reached, or further decrease in air supply after the minimum fuel delivery position has been attained. Provision should be made for manual control for use during starting periods and at such times as the control may be out of service for repairs.

### Feedwater Control Essential

Various types of automatic boiler feedwater control equipment have been on the market for a number of years but the progress in power plant design, especially in central stations, has been such during the past few years that former types of feedwater regulators are not entirely satisfactory for the high-pressure, high-rating, small-storage boilers being installed in some plants today.

Many of the most common types of single-element feedwater regulators have regulator valves which are, in effect, geared to the water level. In other words, as the water level rises, the feedwater flow is shut off and vice versa. Assuming that the same actual weight of water is maintained in the boiler during load changes, the apparent level of water in the drum will rise with an increase of boiler load and shrink with a decrease in the rate of steaming, due to the increase in the volume of steam bubbles below the surface of the water with increased load. This condition will cause the single-element regulator to shut off the water at times of increased load and to increase the flow of feedwater at times of decreased steam demand.

With a three-element feedwater control system, incorporating steam-flow, water-flow and water-level elements, a definite feedwater flow is called for in order to maintain the balance point in a neutral position, for every desired relation of water flow and steam flow. The feedwater valve position is made entirely independent of water level or any one of the three factors involved.

Basically, the three-element feedwater control is designed to maintain a feedwater flow at all times exactly equal to the rate of steam flow. Under such conditions, the water level, as shown by the gage glass, will be low at low rates of steaming and high at high rates of steaming. This has the additional advantage of providing a safety margin of water storage at high rates of steaming to protect against a sudden loss of load, which would tend to drop the water out of the boiler drum and possibly result in the burning of tubes. This system will also permit a sudden increase in load on the boiler, with a corresponding increase in apparent water level due to swell, without the danger of water being carried over into the turbine.

# A. S. M. E. Meeting at Akron October 21-23

OPPORTUNITIES to study the rubber industry in all its details will be afforded the members of the American Society of Mechanical Engineers who attend its meeting in Akron, Ohio, October 21 to 23. Headquarters for the meeting will be at the Portage Hotel, where registration will occur at 9:30 on Monday, October 21. Monday afternoon, an inspection trip will be held to Firestone Tire and Rubber Co. plant and in the evening the dinner, smoker and entertainment will be held at the Firestone Club House and will be addressed by Harvey Firestone, Jr. on the subject of Rubber Plantation Development. Tuesday afternoon, an inspection trip is planned to the Goodyear-Zeppelin plant, Akron Airport and Quaker Oats Co. plants; on Wednesday afternoon, to the B. F. Goodrich Co. plant, Babcock & Wilcox Co. at Barberton, Timken Roller Bearing Co., at Canton and others. The following papers are scheduled for presentation:

Monday, October 21

Applied Mechanics
- Turbine Vibration and Balancing, T. C. Rathbone.
- Stresses and Deflections in Flat Circular Plates and Holes, A. M. Wahl and A. Lobo.

Materials Handling (1)
- Materials Handling in the Plant of the Goodyear Tire and Rubber Co., C. C. Stuber.
- Tramrail Systems and the Fundamentals Which Should be Observed in Their Design and Application, E. T. Bennington.

Education and Training for the Industries
- Apprenticeship in the Rubber Industry, C. C. Slusser.

Tuesday, October 22

Materials Handling (2)
- Incentive Payment Plans Applied to Materials Handling Activities, C. A. Fike.
- Conveying in Tire and Rubber Factories, F. E. Moore.

Aeronautics
- Rubber in Airplane Construction, A. M. Keller.
- Airplane Tires and Wheels, H. F. Schippel.
- Akron's Contribution to Lighter than Air Craft, Hugh Allen.
- Some Fundamental Economics of Aircraft Operation, R. H. Upson.

Wednesday, October 23

Power
- Power and Heat in the Industrial Plant, R. J. S. Pigott.

Iron and Steel
- Billet Chipping, R. S. Haydock.
- German Iron and Steel Developments, W. Trinks.

Management
- The National Elimination of Waste, C. B. Auel.
- Organizing a War on Waste, Raymond Chalmers and W. E. Roe.

It is announced that elaborate entertainment will be provided for the ladies. Further information regarding the meeting can be obtained from the Committee on Arrangements at Akron, of which C. M. Wilkinson is chairman.

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SO-CALLED "SMOKELESS COAL" is a semi-bituminous coal soft and friable with less fixed carbon than semi-anthracite and about half the volatile of bituminous.

# *Tailoring Surface Condensers to Fit**

## How the Most Economical Condenser is Selected for a Given Installation

*By* J. W. ANNE, *Engineer, Conaenser Department*
Elliott Company, Jeannette, Pa.

THERE IS ONE and only one economic condenser for every turbine, assuming a definite basis for making an economic analysis. For any given set of conditions, namely vacuum, quantity of steam to be condensed and average circulating water temperature, there are an infinite number of sizes of condensers which might be offered. The condenser size might vary from an extremely small condenser having a small first cost but an exceedingly high operating charge to an extremely large condenser having a high first cost but a very low operating charge. Between these limits there is, of course, one economic size.

During the past five years, the large purchasers of power plant equipment have come to realize the importance of determining the economic size and have used the economic evaluation of proposals as the basis for making awards of contracts. Quality of product offered must be carefully investigated, but based on equal merit, insofar as quality is concerned, the evaluation determines what equipment should be bought. Thus the old "rule of thumb" method of so many square feet of surface per kilowatt has been superseded by a logical and practical engineering analysis.

Since such an analysis is to be made of proposals after being submitted, it is necessary that each manufacturer offer his most economical type and size of equipment. The selection of the type and size of condenser is not a perplexing problem. It is an exercise in pure logic, supported by mathematical reasoning and based on existing and assumed facts. It is, of course, realized that the solution depends a great deal upon the skill in collecting the necessary data which form the basis for making such an economic study. Some of this data can be obtained from actual measurement; some of it has to be anticipated by observations made in the past. All information which the purchaser will use in evaluating proposals, however, must be disclosed to the manufacturers, if they are to offer their best engineering solution to the problem.

*From an article prepared for Powerfax.

### Actual Installation Used as an Illustration

As stated previously, the size condenser offered for a definite set of conditions can vary over a wide range. Limitations in plant size often impose restrictions which reduce the amount of work required for determining the economic type and size. In order that you may understand how at least one company determines what type and size condenser should be offered, let us take a specification, Table I, as issued recently covering a surface condenser for a large power plant in the central west and follow through the complete study necessary to arrive at the proper solution.

TABLE I. SPECIFICATIONS PREPARED BY CUSTOMERS ENGINEERING DEPARTMENT

| | |
|---|---|
| 1. | Quantity of steam to be condensed at 28.5 in. vacuum | 275,000 lb. per hr. |
| 2. | Quantity of circulating water available | As required by condenser |
| 3. | External head on circulating system | 5 ft. |
| 4. | Average water temperature | 70 deg. F. |
| 5. | Size of condenser | Not specified |
| 6. | Number of passes | Single- or two-pass |
| 7. | Minimum tube size | Single-pass ⅞ in. O.D. Two-pass 1 in. O.D. |
| 8. | Maximum tube length | Single-pass 24 ft. Two-pass 22 ft. |
| 9. | Value of steam per 1000 lb | $0.22 |
| 10. | Change in steam consumption for 0.1 in. Hg. change in vacuum | 1650 lb. per hr. |
| 11. | Rate of capitalization | 15 per cent |
| 12. | Hours operation per year at average load | 6000 hr. |
| 13. | Value of auxiliary power per kilowatt | $0.008 |

TABLE II. TABULATED RESULTS OF TWO-PASS CONDENSER STUDY USING 1-IN. O. D. TUBES 22 FT. LONG

| Sq. Ft. | Vel. | G.P.M. | Vac. | Cond. Friction | Ext. Head | Total Head | H. P. 85% Eff | Pump Charge $48/kw/year | Vacuum Charge | Net Yearly Charge | Yearly Charge Cap. 15% | Initial Cost | Comparative Initial Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25000 | 5 | 21550 | 27.72" | 8.08' | 5.0' | 13.08' | 83.7 | $− 3,000 | $−17,000 | $−20,000 | $133,400 | $ 73,370 | $206,770 |
| | 6 | 25850 | 28.02 | 11.22 | 5.0 | 16.22 | 124 4 | − 4,460 | −10,500 | −14,960 | 99,700 | 74,590 | 174,290 |
| | 7 | 30150 | 28.20 | 14.70 | 5.0 | 19.70 | 176 0 | − 6,310 | − 6,500 | −12,810 | 85,400 | 75,850 | 161,250 |
| 30000 | 4 | 20700 | 27.76 | 5.43 | 5.0 | 10.43 | 64.0 | $− 2,293 | $−16,100 | $−18,393 | $122,500 | $ 85,115 | $207,615 |
| | 5 | 25850 | 28.10 | 8.08 | 5.0 | 13 08 | 100 0 | − 3,580 | − 8,720 | −12,300 | 82,000 | 86,555 | 168,555 |
| | 6 | 31000 | 28.30 | 11.22 | 5.0 | 16.22 | 149 3 | − 5,350 | − 4,350 | − 9,700 | 64,700 | 88,015 | 152,715 |
| | 7 | 36200 | 28.43 | 14.70 | 5 0 | 19.70 | 211 3 | − 7,575 | − 1,500 | − 9,075 | 60,500 | 89,455 | 149,955 |
| 35000 | 4 | 24100 | 28.08 | 5.43 | 5.0 | 10 43 | 74.6 | $− 2,670 | $− 9.150 | $−11,820 | $ 78.800 | $ 98.980 | $177,780 |
| | 5 | 30150 | 28.33 | 8.08 | 5.0 | 13 08 | 115.5 | − 4,140 | − 3,700 | − 7,840 | 52,250 | 100,700 | 152,950 |
| | 6 | 36200 | 28.48 | 11.22 | 5.0 | 16.22 | 174.0 | − 6,235 | − 400 | − 6,635 | 44,200 | 102,360 | 146,560 |
| | 7 | 42200 | 28.58 | 14.70 | 5.0 | 19 70 | 246.5 | − 8,825 | + 1,750 | − 7,075 | 47,150 | 103,900 | 151,050 |
| 40000 | 4 | 27600 | 28.32 | 5.43 | 5.0 | 10 43 | 85 3 | $− 3,055 | $− 3,900 | $− 6,955 | $ 46,400 | $112,630 | $159,030 |
| | 5 | 34500 | 28.46 | 8.08 | 5.0 | 13.08 | 133.7 | − 4,790 | − 850 | − 5,640 | 37,650 | 114,590 | 152,240 |
| | 6 | 41400 | 28.59 | 11.22 | 5.0 | 16.22 | 199.4 | − 7,140 | + 1,950 | − 5,190 | 34,650 | 116,390 | 151,040 |
| | 7 | 48260 | 28.67 | 14.70 | 5.0 | 19.70 | 282.5 | −10,120 | + 3,700 | − 6,420 | 42,800 | 117,990 | 160,790 |

TABLE III. TABULATED RESULTS OF A SINGLE-PASS CONDENSER STUDY USING ⅞-IN. O. D. TUBES 24 FT. LONG

| Sq. Ft. | Vel. | G.P.M. | Vac. | Cond. Friction | Ext. Head | Total Head | H. P. 85% Eff. | Pump Charge $48/kw/year | Vacuum Charge | Net Yearly Charge | Yearly Charge Cap. 15% | Initial Cost | Comparative Initial Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20000 | 5 | 26900 | 27.7″ | 5.02′ | 5.0′ | 10.02′ | 80 | $− 2,765 | $−17,400 | $−20,165 | $134,400 | $ 62,965 | $197,365 |
| | 6 | 32250 | 27.96 | 6.93 | 5.0 | 11.93 | 114 | − 4,080 | −11.800 | −15,880 | 105,800 | 64,525 | 170,325 |
| | 7 | 37650 | 28.13 | 9.15 | 5.0 | 14.15 | 157.8 | − 5,645 | − 8,050 | −13,695 | 91,300 | 66,005 | 157,305 |
| | 8 | 43000 | 28.26 | 11.58 | 5.0 | 16.58 | 211.0 | − 7,550 | − 5,250 | −12,800 | 85,250 | 67,325 | 152,575 |
| 25000 | 5 | 33600 | 28.14 | 5.02 | 5.0 | 10.02 | 100 | $− 3,580 | $− 7,850 | $−11,430 | $ 76,150 | $ 76,865 | $153,015 |
| | 6 | 40300 | 28.31 | 6.93 | 5.0 | 11.93 | 142.7 | − 5,110 | − 4,100 | − 9,210 | 61,400 | 78,725 | 140,125 |
| | 7 | 47000 | 28.435 | 9.15 | 5.0 | 14.15 | 197.2 | − 7,060 | − 1,400 | − 8,460 | 56,350 | 80,325 | 136,675 |
| | 8 | 53750 | 28.525 | 11.58 | 5.0 | 16.58 | 264.5 | − 9,470 | + 500 | − 8,970 | 59,750 | 81,725 | 141,475 |
| 30000 | 5 | 40300 | 28.39 | 5.02 | 5.0 | 10.02 | 119.7 | $− 4,280 | $− 2,400 | $− 6,680 | $ 44,550 | $ 90,675 | $135,225 |
| | 6 | 48400 | 28.52 | 6.93 | 5.0 | 11.93 | 171.1 | − 6,120 | + 400 | − 5,720 | 38,150 | 92,475 | 130,625 |
| | 7 | 56500 | 28.61 | 9.15 | 5.0 | 14.15 | 237.0 | − 8,480 | + 2,400 | − 6,080 | 40,550 | 94,475 | 135,025 |
| | 8 | 64500 | 28.68 | 11.58 | 5.0 | 16.58 | 316.5 | −11,310 | + 3,900 | − 7,410 | 49,300 | 96,375 | 145,675 |
| 35000 | 5 | 47000 | 28.55 | 5.02 | 5.0 | 10.02 | 139.6 | $− 5,000 | $+ 1,100 | $− 3,900 | $ 26,000 | $105,080 | $131,080 |
| | 6 | 56400 | 28.65 | 6.93 | 5.0 | 11.93 | 199 5 | − 7,140 | + 3,250 | − 3,890 | 25,950 | 107,280 | 133,230 |
| | 7 | 65800 | 28.725 | 9.15 | 5.0 | 14.15 | 276 | − 9,880 | + 4,900 | − 4,980 | 33,200 | 109,480 | 142,680 |
| | 8 | 75200 | 28.78 | 11.58 | 5.0 | 16.58 | 369 | −13,200 | + 6,050 | − 7,150 | 47,700 | 111,680 | 159,380 |

From the foregoing data, we, of course, cannot definitely state whether a single- or two-pass condenser would be the most economical, neither can we say offhand what size should be offered. Some of the values set forth might indicate that the single-pass condenser will have the advantage, but, as we have always maintained, the question of whether a condenser should be single- or two-pass depends primarily upon plant facilities and an economic study. We do know from experience, however, that the most economical condenser will probably be the one using the longest practical tube length.

With this in mind, for our first consideration, let us assume a two-pass condenser using 1-in. O.D. tubes, 22 ft. long. We will assume sizes of condensers varying from 25,000 to 40,000 sq. ft. at increments of 5000 sq. ft. and circulate through these condensers sufficient water to vary the water velocity through the tubes from 4 to 7 ft. per sec. Each condenser size and definite water velocity for the quantity of steam specified and average circulating water temperature, will establish a definite vacuum. The vacuum maintained reflects back on the prime mover insofar as the steam consumption is concerned. We have specified that the change in the steam consumption for each 0.1 in. Hg. change in vacuum from 28.5 in. amounts to 1650 lb. per hr., or if computed on the basis of 6000 hr. operation a year and 0.22 per 1000 lb. of steam, amounts to $2,180.00 per yr. The vacuum charge against each condenser considered can thus be readily computed.

### Auxiliary Charges Must Be Included

In addition to the vacuum charge, we have the auxiliary power charges, of which we can neglect the charges against the air ejector and condensate pumps as they would be constant. The other auxiliary charge, namely circulating pump charge, can readily be computed provided we determine the pumping head and pump efficiencies. In our analysis 85 per cent pump efficiency was used. The external head on the circulating system was specified as 5 ft. and to this the condenser friction, made up of water-box losses and tube

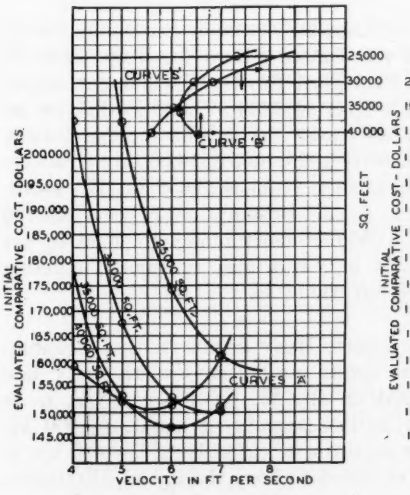


FIG. 1. 35,000 SQ. FT. PROVES TO BE THE MOST ECONOMICAL SIZE FOR A TWO-PASS CONDENSER WITH 1-IN. O. D. TUBES 22 FT. LONG

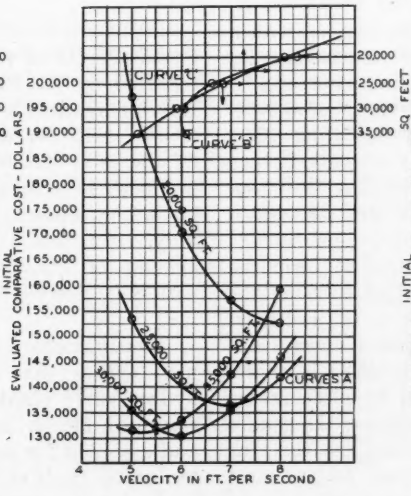


FIG. 2. 32,500 SQ. FT. IS THE MOST ECONOMICAL SIZE FOR A SINGLE-PASS CONDENSER WITH ⅞-IN. O. D. TUBES 24 FT. LONG

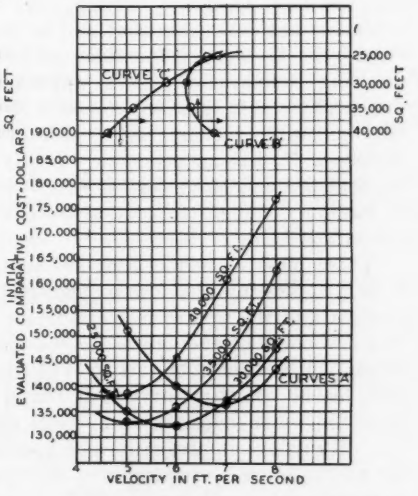


FIG. 3. 31,250 SQ. FT. IS FOUND TO BE THE MOST ECONOMICAL SIZE FOR A SINGLE-PASS CONDENSER USING ⅞-IN. O. D. TUBES 23 FT. LONG

TABLE IV. TABULATED RESULTS OF A SINGLE-PASS CONDENSER STUDY USING ⅞-IN. TUBES 23 FT. LONG

| Sq. Ft. | Vel. | G.P.M. | Vac. | Cond. Friction | Ext. Head | Total Head | H. P. 85% Eff. | Pump Charge $48/kw/year | Vacuum Charge | Net Yearly Charge | Yearly Charge Cap. 15% | Initial Cost | Comparative Initial Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25000 | 5 | 35050 | 28.17″ | 4.85′ | 5 0′ | 9 85′ | 102 6 | $− 3.670 | $− 7.200 | $−10.870 | $ 72.470 | $ 78.805 | $151.275 |
| | 6 | 42050 | 28.335 | 6.69 | 5.0 | 11 69 | 146 2 | − 5.235 | − 3.600 | − 8.835 | 59.300 | 80.655 | 139.955 |
| | 7 | 49050 | 28.46 | 8.83 | 5 0 | 13 83 | 202 0 | − 7.230 | − 850 | — 8.070 | 53.900 | 82.305 | 136.205 |
| | 8 | 56050 | 28.53 | 11.17 | 5.0 | 16 17 | 269 5 | − 9.600 | + 650 | − 8.950 | 59.650 | 83.905 | 143.555 |
| 30000 | 5 | 42100 | 28.41 | 4.85 | 5 0 | 9.85 | 123 | $− 4.405 | $− 1.950 | $− 6.355 | $ 42.300 | $ 92.775 | $135.075 |
| | 6 | 50500 | 28.53, | 6.69 | 5.0 | 11.69 | 174.8 | − 6.260 | + 650 | − 5.610 | 37.350 | 94.775 | 132.125 |
| | 7 | 58900 | 28.62 | 8.83 | 5.0 | 13 83 | 242 | − 8.670 | + 2.600 | − 6.050 | 40.300 | 96.775 | 137.075 |
| | 8 | 67400 | 28.69 | 11.17 | 5 0 | 16 17 | 323 5 | −11.570 | + 4.100 | − 7.470 | 49.800 | 98.775 | 148.575 |
| 35000 | 5 | 49100 | 28.56 | 4.85 | 5.0 | 9.85 | 143 4 | $− 5.135 | $+ 1.300 | $− 3.835 | $ 25.550 | $107.480 | $133.030 |
| | 6 | 58900 | 28.66 | 6.69 | 5.0 | 11 69 | 204 5 | − 7.320 | + 3.450 | − 3.870 | 25.800 | 109.880 | 135.680 |
| | 7 | 68700 | 28.73 | 8.83 | 5 0 | 13 83 | 281 5 | −10.080 | + 5.000 | − 5.080 | 33.850 | 112.080 | 145.930 |
| | 8 | 78500 | 28.785 | 11.17 | 5.0 | 16.17 | 376 | −13.460 | + 6.200 | − 7.260 | 48.300 | 114.480 | 162.780 |
| 40000 | 5 | 56050 | 28.66 | 4.85 | 5 0 | 9 85 | 164 4 | $− 5.870 | $+ 3.450 | $− 2.420 | $ 16.150 | $122.325 | $138.475 |
| | 6 | 67300 | 28.73 | 6.69 | 5.0 | 11.69 | 233 5 | − 8.360 | + 5.230 | − 3.130 | 20.890 | 124.825 | 145.115 |
| | 7 | 78500 | 28.803 | 8.83 | 5.0 | 13.83 | 323.0 | −11.565 | + 6.550 | − 5.015 | 33.400 | 127.525 | 160.925 |
| | 8 | 89800 | 28 85 | 11.17 | 5.0 | 16.17 | 426.0 | −15.420 | + 8.350 | − 7.070 | 47.150 | 130.225 | 177.375 |

friction, was added. The charge for a kilowatt per year amounted to $0.008 × 6000, or $48.

Thus the net yearly operating charge is the algebraic summation of the vacuum charge and the circulating pump power charge. It is to be borne in mind that the vacuum charge can be either an addition or subtraction depending upon whether the vacuum maintained is above or below 28.5 in. This net yearly charge must be capitalized at the specified rate before adding it to the initial cost to determine the comparative cost. The initial cost can be computed, knowing what equipment is to be furnished.

The results of our calculations on the two-pass condenser are shown in Table II. From this you will see that each size condenser has an economic vacuum, but of the condensers selected, there is but one economic size which should be offered. Figure 1 shows the results of our calculations in curve form.

The first set of curves, designated as A, have been determined by plotting the velocity of water through the tubes as the abscissa and the comparative cost in dollars as the ordinate. You will see from these curves that the most economic vacuum for the 25,000-sq. ft. condenser is the vacuum that will be maintained with a water velocity through the tubes of 7.9 ft. per sec. Its resulting comparative cost is approximately $158,100. The 30,000-sq. ft. has an economic velocity of 6.8 ft. per sec. with a comparative cost of $149,700. The 35,000-sq. ft. has an economic velocity of 6.05 ft. per sec. and a comparative cost of $146,700. The 40,000-sq. ft. has an economic velocity of 5.65 ft. per sec. and a comparative cost of $150,500.

These most economic sizes are plotted to form the B curve, plotting the lowest comparative costs as the abscissa and the square feet of surface as the ordinate. The low point of this curve, or the most economic size which can be offered of this type of condenser is, therefore, 35,000 sq. ft. Curve C is found by plotting the economic water velocities as abscissa against the square feet of surface as ordinate, and you will see that for the most economic size, namely, 35,000 sq. ft., the most economic water velocity is 6.05 ft. per sec. This is the best two-pass condenser which can be offered.

In the same way, we analyze the single-pass, ⅞-in. O.D. proposition. In this case the maximum tube length of 24 ft. should be used. The results of our calculations are shown in Table III and in Fig. 2. Curve B indicates the most economical ⅞-in., 24-ft. tube proposition to be 32,500 sq. ft., with an economical water velocity of 5.5 ft. per sec. as indicated from curve C. The comparative initial cost of this most economical single-pass condenser is approximately $130,000 as against $146,700 for the most economical two-pass condenser. Therefore, the single-pass condenser is our best offering.

To convince ourselves, however, that no shorter tube length might be more economical, let us go through the same procedure for a ⅞-in. O.D., single-pass unit, using 23-ft. tubes. The results of our calculations are shown in Table IV and in Fig. 3.

The most economical 23-ft. single-pass condenser is therefore 31,250 sq. ft., as indicated from curve B, with a water velocity of 5.68 ft. per sec. as determined from curve C. The comparative initial cost is approximately $132,000 or $2000 more than the 24-ft. proposition. Therefore, the proper offering is a 32,500-sq. ft. single-pass condenser using ⅞-in. O.D. tubes, 24 ft. long.

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PRODUCTION OF ELECTRIC POWER by the Public-Utility Power Plants in the United States for July, 1929, as reported by the Geological Survey Department of the Interior, reached a total of 8,011,077,000 kw-hr., an increase of 12 per cent over the output for July, 1928. Of the total for July, 1929, 4,951,516,000 kw-hr. were produced by fuel and the balance, 3,059,561,000 kw-hr. by water power. Total consumption of coal during July, 1929, was 3,585,058 short tons. Fuel oil in the amount of 710,778 bbl. was also consumed, together with 8,710,808,000 cu. ft. of natural gas.

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BEAUHARNOIS LIGHT, HEAT & POWER CO., Beauharnois, Quebec, has begun preliminary work on a new hydroelectric plant on the St. Lawrence River, to be equipped for an initial capacity of about 200,000 hp. and designed for an ultimate capacity of 500,000 hp. in ten units. It is expected to have the initial installation ready for service in about 36 mo. In the meantime, a contract has been arranged with the Shawinigan Water & Power Co. for the necessary power supply for construction work.

# Efficiencies of High-Pressure Steam Turbines

INVESTIGATION OF HIGH PRESSURE TURBINE TESTS LEADS TO THE CONCLUSION THAT TURBINE EFFICIENCIES ARE A FUNCTION NOT ONLY OF THE PARSONS CHARACTERISTIC BUT OF THE WEIGHT OF STEAM GOING THROUGH THE TURBINE AS WELL. BY DR. ING. MELAN*

BASED UPON the steam condition ahead of the turbine and the horsepower delivery at the coupling, the efficiency of the turbine decreases with increasing pressure. This is caused principally by losses due to leakage in higher steam pressure, although there are other losses which tend to accentuate this change.

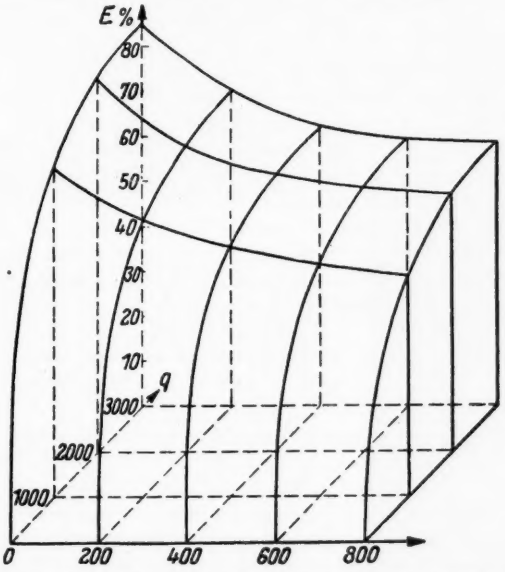


FIG. 1. VARIATION IN TURBINE EFFICIENCY SHOWN AS A FUNCTION OF TWO VARIABLES, THE PARSONS CHARACTERISTIC q AND A FACTOR S, A FUNCTION OF THE PRESSURE DROP, ADIABATIC HEAT DROP AND STEAM FLOW

More recent investigation, principally the investigations carried on by the Siemens-Schuckertwerke, have shown that the efficiency of the steam turbine, broadly speaking, depends not only on the Parsons characteristic $q = \Sigma u^2 \div H$, or summation of the circumferential speed square divided by the adiabatic drop, but also upon the average steam flow through the turbine, this latter factor being embodied in the following expression:

$$S = (P_1 - P_2) \div (D \times H)$$

which is equivalent to the pressure difference ÷ (steam flow × adiabatic heat drop).

For a given steam condition, this reduces to a constant ÷ average volume.

Thermal efficiencies, therefore, are brought into a double relationship which can be illustrated in the three dimensional diagram, Fig. 1, which was prepared for saturated steam conditions. This applies only to single expansion turbines, in bleeder or multiple cylinder turbines, the efficiencies of each blade section must be considered separately in respect to the steam flow of that particular section.

This value S of the turbine increases with an increasing initial pressure $P_1$, and decreases with an increase in steam flow D, flow through the turbine being determined primarily by the pressure or adiabatic heat drop and must, therefore, be figured for each individual

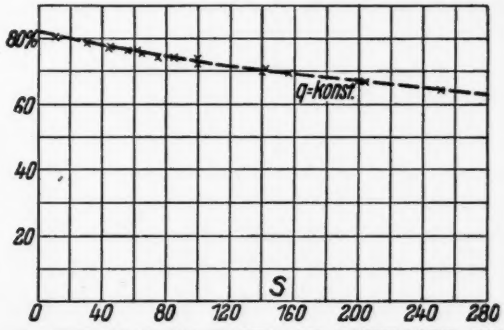


FIG. 2. EFFICIENCIES BASED ON SATURATED STEAM CONDITIONS AND CORRECTED TO A CONSTANT q FOR A NUMBER OF DIFFERENT TURBINES OPERATING UNDER DIFFERENT CONDITIONS

operating condition. If the value S is given for saturated steam, the actual efficiency is obtained by using correction factors which are greater than unity for the superheated field and smaller than unity for the wet steam field.

Values given in the table show that capacity does not control the efficiency, as the efficiency is primarily dependent upon the above definite value S.

*Chief Engineer, Dept. of Central Stations, Siemens-Schuckertwerke-A.G., Berlin, Germany. From an article in Siemens-Zeitschrift.

TEST DATA OF VARIOUS TURBINE UNITS OPERATING UNDER A WIDE RANGE OF STEAM CONDITIONS

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Full load, h.p. | 2,800 | 2,800 | 900 | 3,400 | 2,450 | 10,000 |
| Throttle pressure, lb. per sq. in. abs. | 189.8 | 190.0 | 199.8 | 473.8 | 728 | 1,245 |
| Throttle temperature, °F. | 613 | 566 | 572 | 727 | 824 | 716 |
| Back pressure, lb. per sq. in. abs. | 48.7 | 47.4 | 21.4 | 184.5 | 313.9 | 308 |
| Exhaust temperature, °F. | 373 | 323 | 266 | 530 | 651 | 430 |
| Amount of steam, lb. per hr. | 64,200 | 68,800 | 18,380 | 101,300 | 79,300 | 238,200 |
| Adiabatic heat drop, H° B.t.u. | 301.6 | 285.7 | 424.5 | 236.0 | 226.2 | 301.7 |
| Factor ξ | 73.5 | 72.5 | 229 | 121 | 232 | 140 |
| Factor q | 5,236 | 5,412 | 3,662 | 6,891 | 4,612 | 6,375 |
| Efficiency, as determined | 81.3 | 80.0 | 67.5 | 78.5 | 75.5 | 77.7 |
| Saturated steam efficiency, calculated to q=5426 | 77 | 77.1 | 69.8 | 75.0 | 70.8 | 74.2 |

The influence of the Parson characteristic upon the efficiency is about the same for the entire range of S = 0 to S = 800 which is available today. Therefore the efficiency of various turbine constructions can be brought with some proximity to a relative efficiency figure for comparative figuring as has been done in Fig. 2 from data in the table. This shows that two entirely different turbines from columns 3 and 5, one operating at 200 lb. and the other at 725 lb., have about the same relative efficiency. For small ranges of S, the efficiency E based upon the same conditions may be represented by the equation

$$E = a - bS$$

in which a and b are to be considered as constant for small differences of S.

Upon the basis of efficiency values arrived at in this article, it is now possible to predict efficiency values over a wide range of initial pressures and for various

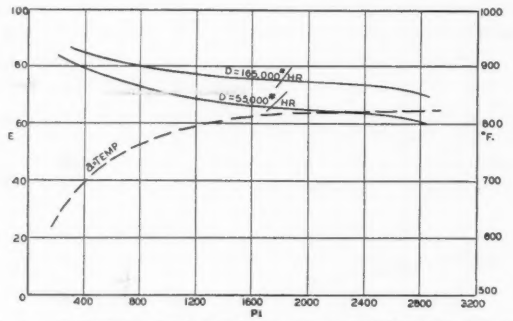


FIG. 3. TURBINE EFFICIENCY AS A FUNCTION OF THE INITIAL PRESSURE TO SHOW THE EFFECT OF LOAD UPON THE TURBINE EFFICIENCY

steam flows to the turbine under constant back pressure conditions. This has been done in Fig. 3 for steam flows of 55,000 and 165,000 lb. per hr. of steam for different initial pressures, the back pressure having been kept at about 57 lb. per sq. in. absolute. In this case, it was assumed that the inlet temperature increased with the increased initial pressure, the highest inlet temperature being about 800 deg. F.

This method may be used to find the admissible pressure limit with which a turbine can still be operated at a definite steam flow or the curves may be supplemented with intermediate values and be a guide for selecting the most favorable boiler pressure in designing a power plant.

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AT THE COOS BAY STATION of the Mountain States Power Co., North Bend, Oregon, a 10,000-kw. addition is scheduled for completion by July, 1930. This will increase the capacity of the present station from 5000 to 15,000 kw. The addition to the Coos Bay Station will include one 10,000-kw. turbine with two boilers of suitable capacity. Erection of one boiler in addition to these two is now in progress and baffle wall has been completed and erection of the superheater and structural steel work has been started.

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FOR FILLING iron thermometer wells, the following materials have been found satisfactory for the temperatures given: Mercury up to 500 deg. F., solder 500 to 1000 deg. F., tin 600 to 1800 deg. F.

# Tests of Bituminous Caking Coal in Low-Pressure Heating Boiler

WHEN BITUMINOUS COAL is burned in a hand-fired up-draft boiler used for heating purposes, it has a decided tendency to produce smoke. A design of furnace and a method of firing and attendance that are satisfactory for fuels low in volatile matter, as anthracite or coke, are not necessarily satisfactory for bituminous coals. It is therefore becoming common practice to use a special design of furnace for bituminous coals, in order to facilitate the combustion of the volatile matter and soot. This is done by providing a larger combustion space to give more time for the combustion, construction that will produce a better mixing of the gases and secondary air supplied over the fuel bed, or keeping the gases at a higher temperature by preheating the secondary air, as may be done by surrounding them with refractory surfaces or causing them to pass through a fuel bed of hot coke. A furnace may be built to use any or all of these methods of smoke prevention.

In Bureau of Mines Technical Paper 303, the results of tests on a large heating boiler when burning coke, anthracite and bituminous coal were outlined. Certain alternative furnace arrangements were used but there was no material change in the furnace design for the various fuels. Since that time, the manufacturer has made modifications in design to adapt it for use of bituminous coal, and additional tests have been made by the Bureau of Mines to determine how this change affected the production of smoke and the efficiency of the boiler.

Conclusions drawn from this later series of tests are set forth as follows in Serial 2943, recently issued by the Bureau of Mines: The boiler and furnace efficiency for five tests using tuyeres for secondary air averaged only 1 per cent higher than for the three tests when secondary air was admitted through slots in the fire-doors. Less carbon monoxide was present in the flue gases in tests with secondary air through tuyeres than in tests with air through slots in the furnace doors. Less smoke was measured by the Ringelmann chart method in tests with tuyeres than in those with slots in furnace doors but the smoke was not materially reduced. In all tests, the smoke emission was at times in excess of that permitted by the smoke ordinance for the City of Pittsburgh.

There was increased resistance to flow of gases through the boiler with tuyeres for the secondary air, as shown by the difference in draft measured just inside the furnace door and at the end of the last pass. This increased resistance required about 15 per cent additional draft to obtain a steam output from the boiler with tuyeres similar to the output with slots in furnace doors to admit secondary air.

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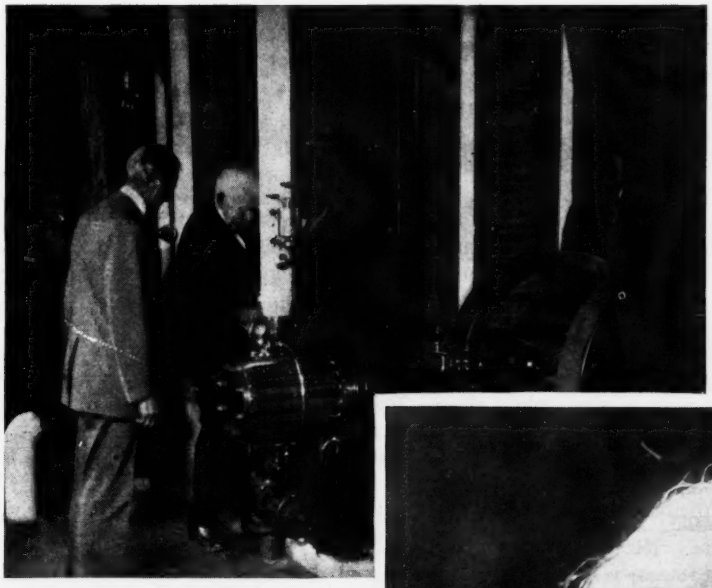
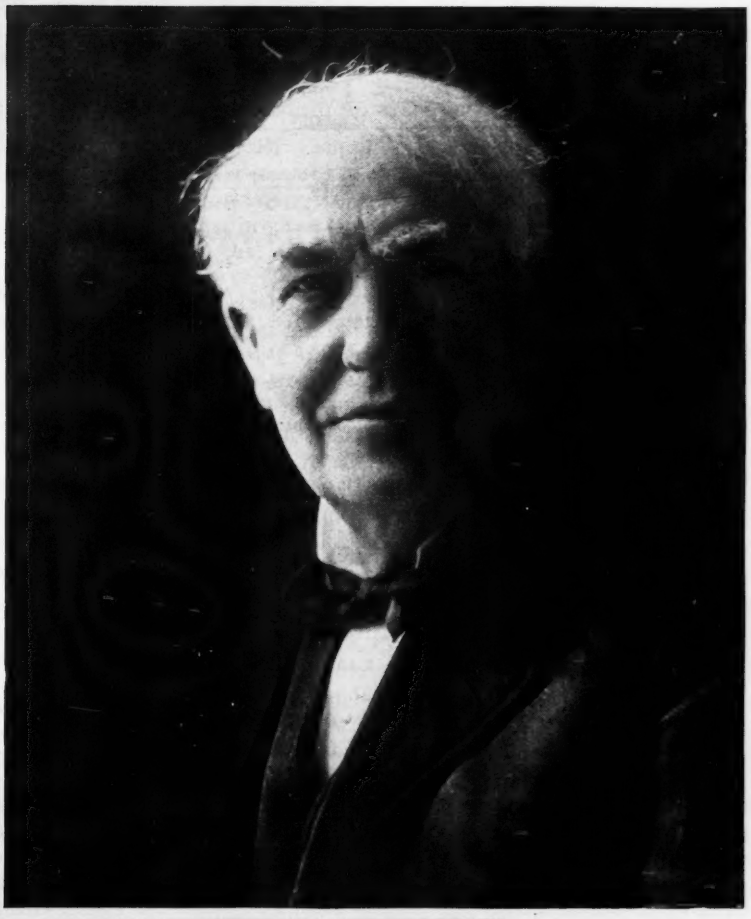
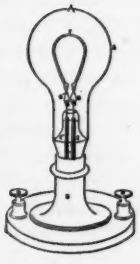
AUGUST SALES of mechanical stokers, as reported to the Department of Commerce by the 10 leading manufacturers in the industry, totaled 199, installed under boilers of 54,929 hp. capacity as compared with 186 stokers under 65,197 hp. in July and 162 stokers under 51,572 hp. in August, 1928. Of the 199 stokers sold in August, 1929, 94 were for installation under 13,981 hp. of fire-tube boilers and 105 for use under 40,948 hp. of water-tube boilers.



# Thomas Alva Edison



TO Thomas Alva Edison, producer of the first commercially successful incandescent lamp and of the distribution system for making it available, discoverer of fundamental principles and their application in the fields of telegraphy, telephony, the phonograph, the motion picture and a host of others, the entire world on October 21 will lift up its voice in a great outpouring of admiration and affection. This page adds the tribute of Power Plant Engineering to a man whose sole objective has been the search for truth, rather than the ruthless use of men and materials for selfish purposes. The celebration of Light's Golden Jubilee, commemorating the 50th anniversary of the building of the first incandescent lamp, centers about Dearborn, Mich., where Henry Ford has reproduced Edison's original Menlo Park laboratory, as shown below.



# Diesel Engine Power Costs

Operating Costs of Well Designed and Modernly Equipped Diesel Plant of Vulcan Rail & Construction Co. By Edgar J. Kates*

NUMEROUS REPORTS on Diesel power costs are being published but some of these reports are of little value to engineers and managers who are considering installing Diesel engines, because they do not show the costs to be expected in a well operated Diesel power plant of modern design, in which, of course, the prospective user is interested today. He is certainly not concerned with plants of ancient vintage, with plants that are negligently operated, nor with plants in which cost records are kept according to accounting systems set up by state public utility commissions and which do not apply at all to private power plants.

## Actual Costs on Properly Equipped Plant

For these reasons, actual cost data on a well designed and well operated modern Diesel power plant should prove welcome. This plant, which went into service in March, 1928, consists of a 240-hp. six-cylinder Diesel engine direct-connected to a 160-kw. generator. It supplies the entire power requirements of the Vulcan Rail & Construction Co. of Maspeth, N. Y., whose plant consists of a structural iron works containing not only the usual equipment of punches, presses and cranes, but also electric arc welding equipment with an irregular current demand. The power plant also contains two motor-driven air compressors for supplying various air tools as well as an air hammer. Automatic controls of various kinds were provided in order to reduce the required amount of supervision. It is in charge of a toolroom machinist who is regularly occupied at his bench in the adjoining toolroom. All that this man needs to do is to start and stop the engine and occasionally to inspect it. A laborer spends a few hours a week in cleaning the lubricating oil purifier and in keeping the plant clean. This plant has not suffered a single forced shutdown since it was started.

Operating data and costs on this plant from the time it was put in service in March, 1928, are shown in the accompanying table which includes the monthly records from January to July, 1929. For the present year, the average running time per month has been 214 hr. and the average load only 37 per cent of rated capacity, yet the power production cost was only 1.2 cents per kw-hr. This cost included a liberal allowance of $30 per month for maintenance. Actually the cost of maintenance has averaged only $7 per month but a reserve is being built up to take care of the future cost of replacing pistons, cylinders and bearings when these parts shall have worn out.

OPERATING DATA AND COSTS OF DIESEL POWER PLANT OF VULCAN RAIL & CONSTRUCTION CO.

| Operating Data | March 2 to Dec.31,1928 Aver.per mo. | 1929 January | February | March | April | May | June | July | Averages Jan.1 to July 31,1929 Aver.per mo. | Aver.per kw-hr. |
|---|---|---|---|---|---|---|---|---|---|---|
| Current generated, kw-hrs. | 12,009 | 14910 | 10570 | 15740 | 12640 | 11880 | 11480 | 12110 | 12761 | |
| Hours run | 215 | 222¼ | 180½ | 227½ | 213 | 222½ | 208¾ | 222½ | 213.7 | |
| Average load, kw. | 55.8 | 67.1 | 58.5 | 69.3 | 59.3 | 53.4 | 55.0 | 54.5 | 59.8 | |
| Ratio $\frac{\text{average load}}{\text{rated load}}$ per cent | 34.9 | 42.0 | 36.6 | 43.3 | 37.1 | 33.4 | 34.4 | 34.0 | 37.4 | |
| Fuel oil consumed, gal. | 1430 | 1592 | 1198 | 1575 | 1372 | 1288 | 1234 | 1192 | 1350 | |
| Fuel efficiency, kw-hr.per gal. | 8.4 | 9.36 | 8.81 | 10.00 | 9.20 | 9.23 | 9.30 | 10.2 | 9.46 | |
| Lubricating oil added, gal. | 16 | 15¾ | 12½ | 17¼ | 16¼ | 17 | 14.75 | 16.75 | 15.7 | |
| Lubrication efficiency, rated hp-hrs. per gal. | 3220 | 3380 | 3470 | 3160 | 3150 | 3140 | 3400 | 3190 | 3260 | |
| Operating Cost | | | | | | | | | | |
| Fuel oil (6.05 cents per gal.) | $86.50 | $96.30 | $72.50 | $95.20 | $83.00 | $71.90 | $74.60 | $72.10 | $80.80 | .63 cents |
| Lubricating oil | 11.00 | 10.62 | 8.44 | 11.65 | 8.94 | 9.35 | 8.11 | 9.21 | 9.47 | .07 |
| Attendance | 33.30 | 33.30 | 26.90 | 34.60 | 32.00 | 33.00 | 32.00 | 33.20 | 32.14 | .25 |
| Cooling water | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | .01 |
| Maintenance reserve | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 | .24 |
| Operating cost, dollars per mo. | $161.80 | $171.22 | $138.84 | $172.45 | $154.94 | $145.25 | $145.71 | $145.51 | $153.41 | |
| Operating cost, cents per kw-hr. | 1.34 | 1.15 | 1.31 | 1.09 | 1.23 | 1.22 | 1.27 | 1.20 | | 1.20 cents |

Edgar J. Kates, Consulting Engineer

## Bulk Oil Purchase Reduces Manufacturing Cost

Cost figures given in the table do not take account of an interesting item of saving that the Diesel plant has effected. Formerly about 34,000 gal. of oil has been bought in tank wagon deliveries for use in the factory

*Consulting Engineer, New York City.

heating plant and in the forge furnaces. The price was 8.5 cents per gal. When the Diesel plant was installed, extra large fuel storage tanks were put in so that the oil could be purchased in carload lots, at a delivered price of 6.05 cents per gal., the same oil being burned by the Diesel as had been used in the factory. Thus a saving of $833 a yr. was made on the factory oil bill, representing an equivalent saving of 0.54 cents per kw-hr. of current generated in the Diesel plant.

Important data of the table are shown in graphic form on the chart herewith. It should be noted how closely the fuel efficiency (kw-hr. per gal. of fuel) follows the running load factor, average load ÷ rated load. This is because the running load factor is quite

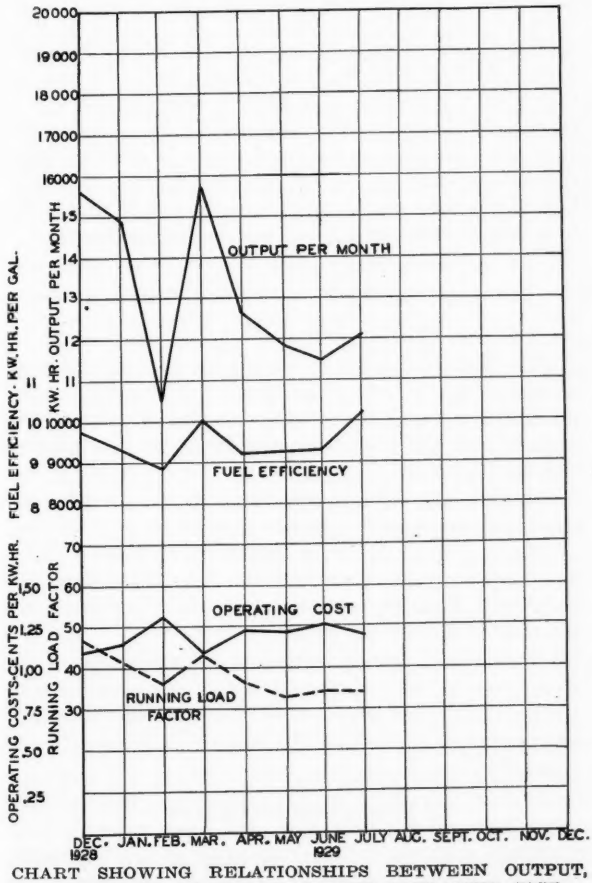

OUTPUT PER MONTH
FUEL EFFICIENCY
OPERATING COST
RUNNING LOAD FACTOR
KW. HR. OUTPUT PER MONTH
FUEL EFFICIENCY-KW.HR. PER GAL.
RUNNING LOAD FACTOR
OPERATING COSTS-CENTS PER KW.HR.
DEC. 1928
JAN. FEB. MAR. APR. MAY JUNE 1929 JULY AUG. SEPT. OCT. NOV. DEC.

CHART SHOWING RELATIONSHIPS BETWEEN OUTPUT, EFFICIENCY, LOAD FACTOR AND OPERATING COST

small, ranging from 33 to 47 per cent, consequently a change in load materially affects the fuel efficiency. If the average load were increased to 60 per cent of rating the fuel efficiency would be greater and the variations less marked.

Fuel efficiency is computed simply from simultaneous readings of the fuel oil meter and the watt-hour meter. This is compared weekly with a reference curve showing fuel efficiency versus load, thus giving an excellent check upon the general condition of the engine.

Previous to the installation of the Diesel engine, the factory was operated by purchased electric power, the cost of which averaged 3.0 cents per kw-hr. plus transformer rental and other charges bringing the cost up to 3.4 cents per kw-hr. With the Diesel plant the cost of producing power has been reduced $379.65 per month and as the entire initial cost of the plant, including two large motor-driven air-compressors for supplying shop air, was $24,000, it is evident that this power plant will pay for itself in less than 6 yr. and thereafter show a clear profit of over $4500 annually. If the shop power requirements increase, as is to be expected, the profits will be still larger, as the additional power will be produced for only the cost of the extra fuel consumed, which will be less than 0.63 cents per kw-hr.

The Diesel engine and air compressors were built and installed by the Chicago Pneumatic Tool Co., the author acting as consulting engineer for the iron works.

## World Power Conference to Meet in Berlin in June, 1930

FORTY-SEVEN countries will be represented in the second plenary meeting of the World Power Conference which will be held in Berlin from June 16 to June 25, 1930, according to information received at the German Tourist Information Office, in New York. Professor Dr. Conrad Matschoss, director of the association of German Engineers and secretary of the Second World Power Conference, is now in this country to discuss preparations with O. C. Merrill, general chairman of the American National Committee of the World Power Conference, and others.

Among the subjects to be discussed at the Berlin Congress are Power Distribution and Utilization, Power Resources of the World, Water Power, Fuels and so on. The main subject around which discussions will center is the development of power supply and power utilization and it is expected that interesting results of practical value for all countries will be attained through the discussion of such subjects as: new fields for the application of power; efficient utilization of generating plants and distribution networks; improvement of load factor; storage of power; advantageous interconnection of different power producing plants; large central plants and large power distribution systems; reduction in costs of construction; effective propaganda and rational tariff systems; coöperation between power producers, power consumers, public authorities, and the legislature; safety measures; information and education.

A comprehensive study and entertainment program is being prepared by the German Committee, of which His Excellency, Dr. O. von Miller, founder and director of the famous German Museum in Munich, is Honorary President, Dr. C. Koettgen (Director-General of Siemens-Schuckert Works) Chairman, Professor Matschoss, Secretary, and Dr. G. Dehne Manager of Organization. The conference will be presided over by an Honorary Committee, at the head of which is His Excellency Staatsrat Dr. Oskar von Miller, the pioneer of electricity supply and founder of the German Museum.

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CENTRAL & SOUTHWEST UTILITIES CO., San Antonio, Texas, a subsidiary of the Middle West Utilities, Inc., Chicago, Ill., is reported to be planning the early construction of a new steam power plant near Laredo, Texas. The proposed plant will have a capacity of 30,000 kw. The transmission system will be connected with the lines from San Antonio to Mexico City, Mexico.

# BULB TYPE RECTIFIERS *for charging* Control Batteries

By E. A. Hoxie
Switchgear Dept., General Electric Co.

DURING THE LAST year or two, the application of bulb type rectifiers to the floating and charging of control batteries has increased to a considerable extent. The most common application is in connection with 24 or 48-v. batteries used in circuit breaker tripping service, but with the advent of rectifiers of this type rated up to a maximum voltage of 150 they may be used to float or charge any voltage control battery up to the nominally rated 125-v. battery of 60 cells provided, of course, the current requirements are not in excess of the capacity available.

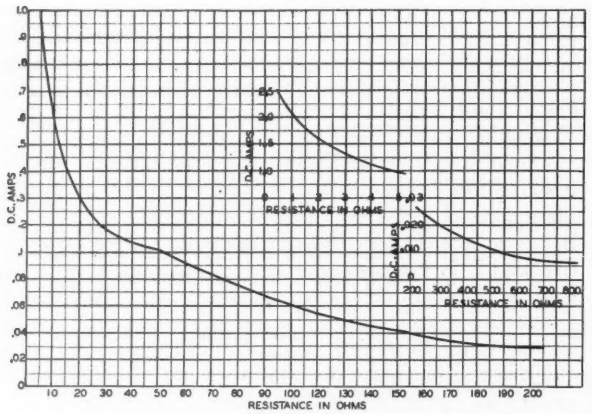


FIG. 1. CHARACTERISTIC CURVES SHOWING VARIATION IN OUTPUT OF BULB TYPE RECTIFIER (24/30 V., 2.5 AMP. D.C.) AT 26 V. WITH VARIOUS AMOUNTS OF RESISTANCE IN D.C. LEADS

Owing to the absence of moving parts and the uniform long life obtained from the bulbs, especially when operated at a fraction of their rated capacity, they have proved both reliable and economical.

A normal life of 5000 hr. is expected from bulbs in this service, although a sufficient amount of data has not yet been accumulated to determine the average life that is actually being obtained. It is not uncommon to hear of a bulb which has operated continuously for a year or more in trickle charge service.

It is customary to include a spare bulb with rectifiers sold for this purpose, and it is of course desirable always to keep a spare bulb on hand.

As a safety measure, it is considered good practice to use only the outfits having transformers of the insulated secondary type as distinguished from autotransformers.

Practically all control batteries are floated although, in installations where the battery furnishes only momentary currents for the tripping of circuit breakers, the battery is occasionally maintained by intermittent charging. In these cases, the battery is charged for a few hours at any convenient rate, but usually at a fraction of the 8-hr. discharge rate, at intervals of a week to a month depending upon the load requirements.

### Floating Method Recommended for Control Batteries

The floating method is usually recommended for all control batteries and is generally favored because of its simplicity and the smaller amount of supervision required but the bulb type rectifier is readily adapted to either method.

In the case of the occasional charge method, the charging rate required is not a definite quantity and satisfactory results may be obtained within wide limits. The means of regulating the current, afforded by the resistance stick or tap switch contained within the rectifier, is usually sufficient.

For floated batteries, however, it is necessary in most cases to insert a variable resistance in series with the load to permit the close and accurate adjustment of voltage which is necessary to obtain maximum life and reliability.

### Regulation of Output

While some rectifiers are equipped with a tap switch giving quite a wide range of output, the regulation afforded by means of these tap switches is entirely too coarse to give satisfactory results. A resistance stick with a movable contact is also included in some rectifiers but, inasmuch as the manipulation of this resistance necessitates opening up the rectifier case and changing the setting by means of a screw driver, the regulation so afforded is quite inadequate. For the sake of convenience, the regulating resistance should be not only capable of close adjustment but also readily accessible.

In some cases, especially where no continuous load is involved, satisfactory results may be obtained by the use of a fixed resistor but, owing to the possibility of some future change in the load and to the inexpensiveness of a small capacity rheostat, it is usually worth while to use one.

### Use of Rheostat and Voltmeter

When equipped with a suitable rheostat and a reliable voltmeter, this close adjustment is very easily and simply obtained and, once properly adjusted, should not require further attention for extended periods provided the continuous load, if any, remains constant.

The variable resistance commonly used is a 6 or 10-in. dial such as is used for generator field rheostats. The resistance required to furnish a certain load at a definite floating voltage cannot be conveniently calculated but curves have been prepared giving this information. A typical curve showing the amount of external resistance required to furnish various loads at a definite floating voltage is shown in Fig. 1.

A sufficient amount of resistance should be included in the rheostat to permit an adjustment of voltage under trickle charge conditions equivalent to 2.15 volts per cell.

To determine the load on the rectifier, especially when the small current taken by the battery is the only load to be furnished, it is necessary of course to have some knowledge of the current taken by the battery under normal floating conditions.

This information may be obtained from the battery manufacturers but, for an approximation, it may be considered that this current averages between 1 and 1½ per cent of the 8-hr. discharge rate.

In order to obtain this current value, the battery must be completely charged and operating long enough with an impressed voltage of 2.15 per cell to become stable.

If a continuous load in addition to the current taken by the battery is to be furnished by the rectifier, this load may be added to the normal average trickle charge current and the resistance required for the sum of these loads may be taken off the curve.

It is usually advisable to make some allowance in the rheostat in excess of the resistance indicated on the curve in order to allow for some variation in the load where there is a continuous load exclusive of the battery load.

### Selecting a Rectifier

In selecting a rectifier to float a control battery, it is necessary to take into consideration the battery capacity and the continuous load on the control bus and also, in some cases, the time required for a complete charge of the battery after some emergency condition which may have caused it to become partially or fully discharged.

A rectifier having sufficient capacity to charge the battery at not less than about 15 per cent of its normal charge rate in addition to any continuous bus load supplied from the rectifier, will be satisfactory, although it is usually considered good practice to include sufficient capacity to permit charging the battery at 25 per cent or more of its normal charge rate.

Owing to the fact that 60-cell batteries are usually of larger capacity than the 24 or 48-v. tripping batteries, the rectifier when applied to 60-cell batteries is only sufficient in most cases to charge the battery at a fraction of its normal charge rate.

In the case of very small capacity, low-voltage tripping batteries, however, the rectifier usually has sufficient capacity to charge the battery at a rate equal to the 8-hr. discharge rate. In some cases involving low-voltage batteries used for tripping only, the rectifier has sufficient capacity to charge the battery at a rate higher than the 8-hr. discharge rate. While it is possible in these cases to adjust the regulating resistance manually to keep the charging rate and voltage within proper limits, it is good practice to include a fixed resistance between the battery and rectifier at all times so that it is impossible to charge the battery at a rate higher than its normal charge rate. In fact, it is usually considered preferable to limit the charging of the battery to a rate less than normal whenever this can be done without unduly increasing the time required for a charge, as the lower charge rates are in general better for the battery.

In the case of these 24 or 48-v. tripping batteries which have no continuous load connected to the bus, no particular harm is done if the voltage during a charge gets up as high as 2.5 per cell or 30 v. for a nominally rated 24-v. battery.

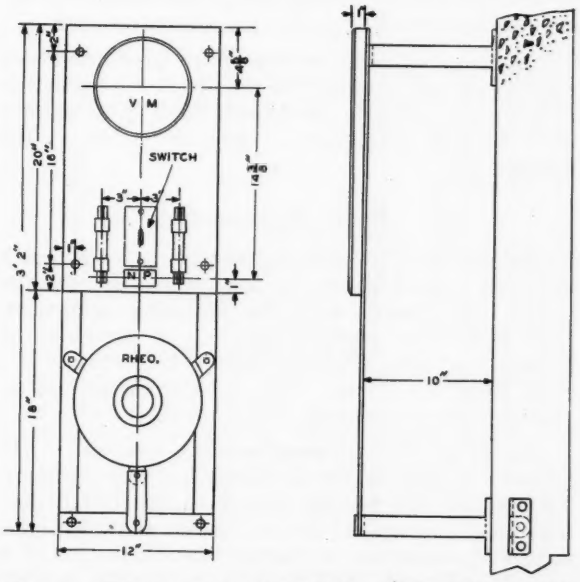


FIG. 2. A TYPICAL WALL MOUNTED PANEL USED IN CONJUNCTION WITH A BULB TYPE RECTIFIER AND CONTROL BATTERY

Due to the drooping characteristic of the rectifier, the voltage during a momentary discharge is usually not more than the maximum allowable operating voltage.

In the case of most 60-cell batteries, however, a voltage in excess of 140 v. on the control bus is decidedly objectionable. While it is true that the large momentary currents required to close the larger breakers will pull the voltage down below the maximum operating limit so that the mechanisms will not be harmed, the other devices such as the operating mechanisms of small circuit breakers, tripping mechanisms and relays may be damaged. Also of greater importance is the harmful effect of the excess voltage on indicating lamps and holding coils requiring current continuously.

If it should become necessary to charge the battery in order to bring it back to a state of full charge, the voltage toward the end of the charge must be adjusted

manually so as not to exceed the maximum limit of 140 v.

It is possible to insert a fixed resistance in the rectifier circuit to prevent the voltage on the battery from going higher than the maximum but it means, in most cases, that it would take considerably longer to charge the battery owing to the lower charging rate throughout the charge. The necessity of this supervision is not often encountered as these batteries are usually maintained for indefinite periods without the necessity of equalizing charges or any charging whatsoever other than that received by the maintenance of normal floating voltage.

The question is frequently raised as to what extent voltage variations in the alternating current affect the direct current. While it is true that these voltage variations will come through to a greater extent than is the case with an induction motor-driven generator, in practically all cases the voltage variations will not be large enough to jeopardize the results obtained.

This is owing partly to the rather large amount of resistance which is usually in the circuit for regulating purposes and partly to the characteristics of the battery itself, both of which have a stabilizing effect on the voltage.

### Panel Equipment

For 60-cell, 125-v. control batteries, it is customary to install a panel which will usually line up with the station switchboard, with the switching equipment, fuses and meters required properly to maintain the battery. In installations of this kind, practically the same panel as is used with trickle charge motor-generator sets would ordinarily be used.

For 24 or 48-v. tripping batteries, however, in the majority of installations no panel has been installed. The rectifier and rheostat have been installed in any convenient location and the only means of checking the voltage impressed on the battery was by the use of a portable voltmeter. This practice has resulted in these batteries receiving insufficient attention and has been generally unsatisfactory.

To meet this condition, it is suggested that the expense of at least a small wall-mounted panel is justified.

This panel should have mounted on it a reliable switchboard grade of voltmeter, a place for mounting the rheostat controlling the rectifier, and battery fuses. The 3-way switch on the rectifier may be used to connect the rectifier to the circuit or, if considered more convenient, a 3-way switch may be mounted on the panel.

An ammeter is not considered essential, as the usual method of maintaining these batteries is to maintain the impressed voltage at or very near to 2.15 v. per cell, in which case the current taken by the battery is automatically corrective. It may also be taken into consideration that some rectifiers include a miniature ammeter mounted on the rectifier case which may serve the purpose in cases where the user desires to have a means of reading current.

Suppressed zero voltmeters having scales of 100-150 have been used to a considerable extent on 60-cell control battery panels as the more easily read scale has been found to be advantageous.

These rectifiers are frequently rated at two voltages, the larger current rating applying to the lower voltage and the smaller current rating to the higher voltage. In applying rectifiers to this service the rating which is of interest is the rating of the rectifier at the maximum allowable voltage of the control bus.

As an example, the rating of a rectifier which has been used to a considerable extent for floating and charging small capacity 60-cell batteries is given as 6/3 amp., 120/150 v. Inasmuch as the maximum permissible control bus voltage for a 60-cell, 125-v. installation is 140, the rating of the rectifier at 140 v. is the rating to be considered in selecting the proper capacity of the rectifier. This rectifier has a rating of 4.5 amp. at 140 v. so that it can be used with any 60-cell battery provided the continuous load plus the current required for charging the battery after an emergency discharge does not exceed 4.5 amp.

## International Heating and Ventilating Exposition

Plans for the International Heating and Ventilating Exposition under the auspices of the American Society of Heating and Ventilating Engineers to be held January 27—31, 1930, at the Commercial Museum, Philadelphia, Pa., are maturing rapidly, according to the Exposition management. Wide range of equipment in this field is to be exhibited, showing the progress in development of unit heaters, house heating equipment, room cooling units, panel heating, boilers and furnaces, radiation equipment, boiler accessories, pipe and piping systems and other equipment.

President Thornton Lewis, of the American Society of Heating and Ventilating Engineers, has announced the following Exposition committees: Advisory committee: H. P. Gant, chairman, York Heating and Ventilating Corp.; A. S. Armagnac, Heating and Ventilating Magazine; D. S. Boyden, Edison Electric Illuminating Co., Boston; W. H. Carrier, Carrier Engineering Corp.; A. C. Edgar, Certified Heating Assn., Inc.; Roswell Farnham, Buffalo Forge Co.; C. V. Haynes, Hoffman Specialty Co.; E. B. Langenberg, Langenberg Mfg. Co.; J. I. Lyle, Carrier Engineering Corp.; F. J. McIntire, United States Radiator Corp.; H. C. Murphy, Reed Air Filter Co.; F. R. Still, American Blower Co.; E. K. Webster, Warren Webster & Co.; and H. L. Whitelaw, American Gas Products Co.

Coöperating committee: O. H. Fogg, President, American Gas Assn.; C. H. Hammond, President, American Institute of Architects; E. M. Fleischman, President, American Oil Burner Assn.; A. J. Wood, President, American Society of Refrigerating Engineers; Walter Klie, President, Heating and Piping Contractors National Assn.; H. T. Richardson, President, National Boiler and Radiator Mfg. Assn.; John W. Meyer, President, National District Heating Assn.; W. C. Hanson, President, National Pipe and Supplies Assn.; C. E. Hall, Director, National Warm Air Heating Assn., and R. T. Creviston, Manager, Plumbing and Heating Industries Bureau. Charles F. Roth, with offices in Grand Central Palace, New York City, is manager of the exposition.

# Electricity---What It Is and How It Acts*

PART XXX. PRODUCTION OF LONG WAVE OR RADIO FREQUENCY ELECTROMAGNETIC RADIATION. BY A. W. KRAMER

THUS FAR IN OUR consideration of electromagnetic radiation phenomena, we have considered only those forms of radiation which occur at the high frequency or short wave end of the spectrum, that is, those forms known as light, ultra-violet rays and x-rays. We will now consider the production and characteristics of radiation which occurs at the low frequency end of the spectrum, that is, those which are known to us as true electric or radio waves. As previously pointed out, all radiation throughout the entire range of the electromagnetic spectrum is very much the same, the difference being due only to differences in wave length or frequency.

The story or the history of the discovery of these electric waves is an interesting one. These waves were predicted, years before they were discovered, in a mathematical treatise on the electromagnetic theory of light by an English scientist James Clerk Maxwell. Maxwell showed that light, heat and these predicted electric waves were all of the same nature. Although at that time there was no evidence of the existence of electric waves, Maxwell described the characteristics and properties they should possess.

Years later, Maxwell's predictions were vertified when a German physicist by the name of Hertz proved the existence of these electric waves by producing and detecting them in his laboratory. Compared to the equipment available today, the apparatus which Hertz had available was crude; nevertheless, with it he not only succeeded in producing and detecting these waves but he measured their length and speed and even reflected them by means of reflectors which he designed. He showed, as Maxwell had predicted, that these invisible waves had the same speed as light and were reflected and refracted in accordance with the same laws as those which governed the reflection and refraction of light. These experiments of Hertz made the way clear for Marconi's development of a system of wireless telegraphy which used these electric waves as a means of transmission. The present art of radio rests on this work of Maxwell, Hertz and Marconi. The whole story is one of the most fascinating in the history of science.

Light waves and x-rays, we have learned, are the result of certain movements of electrons within the atoms of matter. Such waves are characterized by frequencies higher than about 400 million million cycles per second. Radio or electric waves have frequencies which, although high as concerns human experience, are very much lower than those of light, the highest being in the neighborhood of 100,000,000 per sec. and running as low as 15,000 cycles per second. A frequency of 20,000 cycles per second corresponds to a radio wave length of 15,000 meters commonly used in transoceanic radio telegraphy.

Radiation of this type also is produced by the movements of electrons but in this instance it is the result of movements of free electrons in electric conductors. It was shown in Part XII of this series[1] that a moving electric charge sets up around it a magnetic field of force. In other words, when an electron (or a number of electrons) passes through a conductor, the latter will be surrounded by a magnetic field the direction of which is dependent upon the direction in which the electron is moving. If the electron reverses its direction of movement, direction of the magnetic field will reverse. It is evident then that if an alternating current (one which reverses its direction periodically) is made to flow in a conductor, the magnetic field set up by this current will also be an alternating one, the circles of force expanding outward from the conductor when the current is increasing and contracting inward toward the conductor

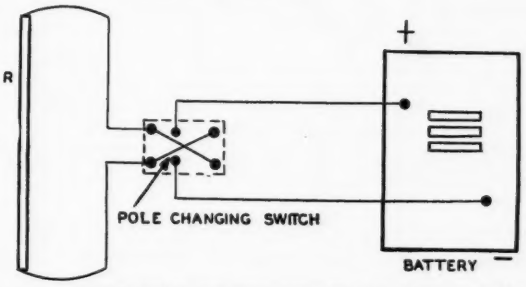


FIG. 1. A CRUDE WAY OF PRODUCING AN ALTERNATING FLOW OF ELECTRONS IN A CONDUCTOR

By means of a pole changing switch current from the battery may be made to flow through the conductor R in either direction. If the handle of the switch is moved rapidly from one side to the other, a low frequency alternating or oscillating current will be set up in the rod R.

when the current is decreasing and reversing their direction when the current passes through zero value and begins to flow in the opposite direction. An electron or a number of electrons moving back and forth along the length of a conductor, therefore, will produce in the vicinity of the conductor an alternating magnetic field.

In a similar manner but with certain differences to be discussed in detail later, an oscillating current is capable of producing an electromagnetic field which, unlike the one described above, will travel outward away from the conductor, never to return. These are electric waves.

## METHODS OF PRODUCING OSCILLATING CURRENTS

Since the production of this form of radiation is dependent upon an oscillating current, before we discuss this kind of radiation, it will be necessary, first, to show how a stream of electrons may be made to oscillate back and forth in a conductor. This can be accomplished in a number of ways, the crudest being merely to connect a battery to a conductor by means of a pole changing switch as shown in Fig. 1 and then rapidly to reverse the switch either by hand or mechanically. A

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[1]Part XII, Nov. 1, 1928.

more logical method, of course, is to substitute for the battery and switch an alternating-current generator. The latter method, in fact, is that used in high-powered transatlantic radio communication.

There is, however, another method which depends upon the discharge of a condenser through a circuit containing an inductance which is used almost universally and which, from a scientific viewpoint, is most interesting of all. A condenser discharging through an inductive circuit is capable of setting up an oscillating current in much the same way that a pendulum oscillates back and forth when drawn to one side and then released.

### Oscillatory Discharge of a Condenser

Suppose a condenser is arranged, as shown in Fig. 2 together with a double-pole, double-throw switch and battery so that by merely throwing the switch, the condenser may be connected either to the battery or to the terminals of the inductive circuit L. If the switch is

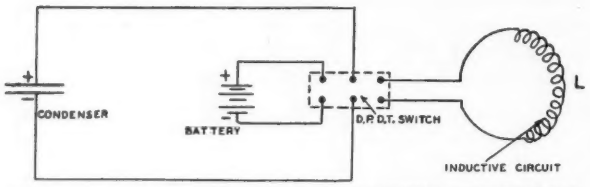


FIG. 2. ARRANGEMENT FOR PRODUCING ELECTRICAL OSCILLATIONS BY MEANS OF A CONDENSER DISCHARGE THROUGH AN INDUCTIVE CIRCUIT

The condenser is first charged by throwing the switch to the left. Then, when the switch is thrown to the right, the discharge takes place through the inductive circuit L.

thrown first to the left, a current will flow from the battery into the condenser until the condenser is fully charged. In this condition, as explained in Part XI,[2] there will be an accumulation of electrons on the upper or positive plate and a deficiency on the lower or negative plate. As a consequence of this unbalanced distribution of electrons, there will be established between the plates an electrostatic field which produces an electromotive force which tends to oppose that of the battery. Current from the battery, therefore, will flow into the condenser until the electromotive force due to the charge on the condenser exactly counterbalances the electromotive force of the battery.

If, after having been charged in this manner, the condenser is suddenly connected to the inductive circuit by throwing the switch lever to the right, the condenser will discharge through this circuit. The discharge current, of course, is opposite in direction to the charge current.

Upon closing the switch on the discharge side, the discharge current from the condenser does not rise to its full value instantly, due to the effect of the inductance in the circuit. The inductance tends to retard the building up of the current. In our discussion of the production of a magnetic field,[3] it may be recalled, the property of inductance was shown to be similar in effect to that of inertia in mechanics. Any attempt to accelerate a stream of electrons in an inductive circuit, it was shown, is met at once by an opposing force called a counter electromotive force which tends to prevent any increase in current. This reactive force is due to the building up of a magnetic field around the conductor.

Thus, when the switch in Fig. 2 is closed, before the current flowing out of the condenser can reach a steady state, a certain portion of the energy stored in the condenser must be expended in producing the magnetic field. The current therefore builds up gradually at a rate which is dependent upon the value of the inductance of the circuit and the instantaneous impressed electromotive force. Since the condenser is discharging, the energy of the system, which was at first stored entirely in the condenser as electrostatic energy, is thus gradually transformed into electromagnetic energy which manifests itself as a field surrounding the conductor. During this time, then, the energy stored in the condenser is expended in two ways, first as heat in overcoming the resistance of the circuit and second in establishing the electromagnetic field. The energy expended in heating the circuit is lost permanently but that expended in establishing the electromagnetic field is returned as will be shown.

When the condenser is fully discharged, the potential across it will be zero. Since there is no longer an electromotive force acting in the circuit, the current naturally will stop. This, however, does not happen instantly. Just as the inductance, when the current first began to flow, tended to oppose any increase in current, now when the current tends to decrease the inductance tends to maintain it.

This action is due to the collapse or contraction of the magnetic field surrounding the conductor.[4] As the circles of magnetic force collapse, they move inward toward the conductor and induce in it a current which is in the same direction as the original discharge current from the condenser.

Thus, the energy stored in the electromagnetic field is returned to the circuit and a current continues to flow in the circuit for some time after the condenser is discharged completely. This current will therefore again charge the condenser but this time in a direction opposite to the original one; that is, the upper plate will be charged negatively and the lower positively.

The conditions now are similar to the original conditions except for the different polarity of the condenser plates and for the smaller amount of energy stored, due to part of the original store having been dissipated in heating the circuit.

The condenser, still being connected to the inductive circuit will again start discharging, this time in a direction opposite to the first. Again, part of the energy will be dissipated as heat and the rest stored in the electromagnetic field. Thus the action will repeat itself with the current flowing in the circuit in alternately opposite directions. With each discharge and charge, however, the total energy of the system becomes less, since with each cycle, a portion is lost as heat.

A condenser discharge through an inductive circuit, therefore, is said to be oscillatory. The action consists of alternate transformations of electrostatic energy into electromagnetic and of electromagnetic into electrostatic, each cycle being accompanied by a loss of a certain portion of the total energy Thus, the oscillations become smaller and smaller until finally they cease.

As already stated, the action is analogous to the

[2]Part XI, October 15, 1928.
[3]Parts XII, XIII and XIV, Nov. 1, Nov. 15 and Dec. 1, 1928 respectively.
[4]Part XIV, Dec. 1, 1928.

action of a pendulum or more properly to a system of a weight attached to the end of a strip of spring steel as shown in Fig. 3. The elasticity of the spring corresponds to the capacity of the condenser in the electric circuit. The mass of the weight or more correctly its inertia, corresponds to the effect of inductance. If the weight is drawn to one side of the center C, potential energy will be stored in the system by virtue of the elastic strain set up in the spring. If under these conditions the weight is released suddenly, the weight under the force exerted by the spring will move toward the central position C. The acceleration is gradual, however, due to the inertia of the weight. It gradually

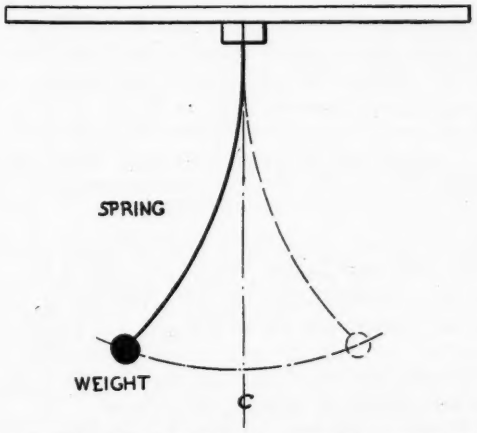


FIG. 3. EQUIVALENT MECHANICAL SYSTEM OF AN ELECTRICAL CIRCUIT CONTAINING BOTH INDUCTANCE AND CAPACITY

This consists of a weight attached to the end of a steel spring, the other end of which is fixed firmly. When the weight is drawn to one side as shown, potential energy is stored in the system. When released, this energy will produce mechanical oscillations, similar to the electrical oscillations set up in a condenser circuit.

gains momentum. When the position C is reached, the condition of strain in the spring will have entirely disappeared as will also the force due to this strain. The weight, however, will not stop moving. As the weight was gradually accelerated, the potential energy of the spring was gradually transformed into kinetic energy and as this kinetic energy is now at a maximum, the weight will be carried beyond the center position C to the opposite side of the "swing" where the energy will once more be stored as potential energy in the spring. This time, the strain is in the opposite direction. If unrestrained, the action will be repeated until the entire store of energy has been dissipated as heat. The similarity between the electrical and mechanical conditions will be obvious.

### Effect of Resistance

In both the electrical and mechanical systems, it is evident that the number of cycles or the number of oscillations which the system undergoes before the energy has all been dissipated, is dependent directly upon the value of the resistance in the circuit. The greater the resistance the smaller will be the number of oscillations and the greater will be the decrease in amplitude of successive oscillations. In the mechanical system, a condition can be conceived easily which will entirely prevent the system from oscillating.

Suppose that the entire arrangement of weight and spring is immersed in a viscous fluid such as heavy oil or syrup. If the viscosity of the liquid is sufficiently high, it is possible that the system will come to rest after the first quarter of a cycle, that is, immediately after the weight has moved from one extreme position to the center.

Similarly in the electric circuit, if the resistance of the circuit is high enough, the oscillations will cease after only a portion of a cycle. The electrical reason for this will be clear if we consider the manner in which the potential due to the charge in the condenser varies with the current. When the condenser first begins to discharge, the difference of potential across its terminals is a maximum and the current, zero. As the condenser discharges, the current gradually increases, although the electromotive force due to the charge gradually decreases. This may seem paradoxical but it must be remembered that, during this time the energy of the system is being transformed from potential into kinetic and that a magnetic field is being established at a rate which varies directly as the rate at which the electromotive force is decreasing; hence as the electromotive force approaches zero the rate at which the magnetic

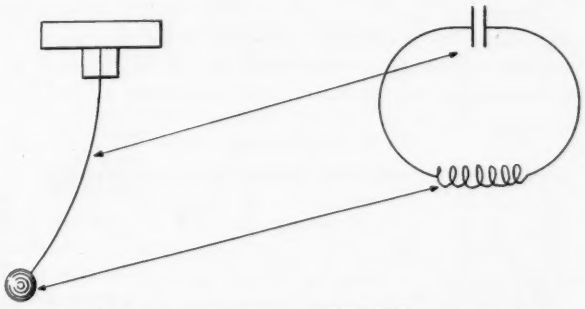


FIG. 4. DIAGRAM SHOWING SIMILARITY BETWEEN MECHANICAL AND ELECTRICAL OSCILLATORY SYSTEMS

field is being formed is decreased, resulting in an increase in current.

If the resistance of the circuit is high, however, the electromotive force acting on the circuit may be reduced so much during the discharge that it cannot bring about a further increase of current through the resistance. Then since the electromotive force across the condenser continues to decrease as long as the current is flowing, the current and electromotive force will both decrease together and approach zero as the energy of the original charge is dissipated in heat. There will thus be no store of electromagnetic energy set up in the circuit and the condenser will not be recharged.

It must be evident that the rate or frequency at which the oscillations occur is determined by the values of inductance and capacity in the circuit just as the rate of vibration of the mechanical system in Fig. 3 is determined by the values of mass and elasticity of the weight and spring respectively.

It was stated that, in the oscillatory discharge of a condenser, a certain portion of the energy during a cycle was radiated as heat. Since this loss occurs during each cycle, it is obvious that after a certain length of time the entire store of energy will have been dissipated in this manner. For this reason, the successive oscil-

lations will be of decreasing amplitude; that is, the successive maximum values of current will decrease.

In Fig. 4 is depicted graphically the oscillatory discharge of a condenser. The maximum amplitudes $a_1$, $a_2$, $a_3$, etc. at each reversal, it will be noted, grow smaller until finally the oscillations are too small to be seen. Such a wave is said to be damped.

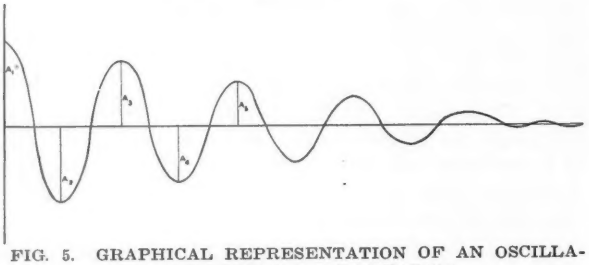

FIG. 5. GRAPHICAL REPRESENTATION OF AN OSCILLATORY CONDENSER DISCHARGE

Showing the decay of successive oscillations as the energy is dissipated as heat.

The analogy between the mechanical system of Fig. 3 and the electrical circuit holds here also, for the amplitude of vibration of the mechanical system decreases in the same way.

From the above discussion, then, it is seen that an alternating or oscillatory current may be obtained in a circuit containing a condenser and an inductance by first charging the condenser and then letting it discharge

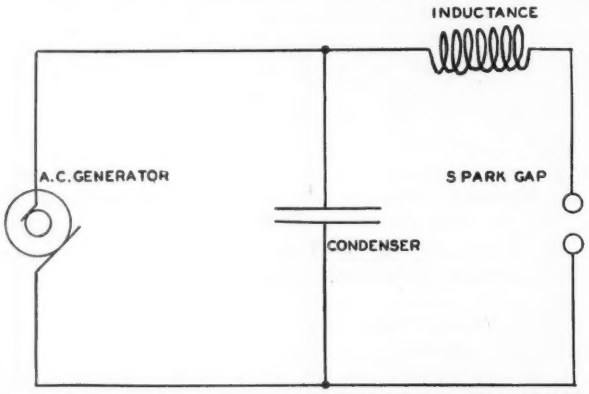


FIG. 6. CIRCUIT FOR CONTINUOUSLY GENERATING ELECTRICAL OSCILLATIONS

The condenser, charged by the a. c. generator, will commence to discharge across the spark gap when the potential is such as to break down the insulating properties of the spark gap. When the electromotive force is reduced to a value when it will no longer maintain a current across the gap, the insulating property of the gap will be re-established and the process will repeat itself.

through the inductance. The frequency of this alternating current is a function of the values of the inductance and capacity of the circuit and may be made anything between extremely wide limits. Frequencies as low as one-half cycle per second have been obtained on the one hand while, on the other, frequencies of 300 million per second have been produced. The frequency produced in a circuit in this manner is said to be the natural frequency of the circuit.

The life of such a wave train as is produced by a condenser discharge is extremely short, in general not more than an exceedingly small fraction of a second. To produce such oscillatory currents continuously, it is necessary to provide a means whereby the condenser may be recharged immediately after it has been completely or partially discharged. This can be done by an arrangement such as is shown in Fig. 6. In this circuit, a high-voltage alternating-current generator is connected permanently across the terminals of the condenser which the discharge circuit in addition to an inductance has connected into it a spark gap.

The alternating-current generator produces an electromotive force which varies from zero to maximum and back to zero in one direction and then reverses and rises to a maximum in the opposite direction. This is shown graphically in Fig. 7.

As the generator voltage rises from zero to maximum, the condenser in Fig. 6 of course will become

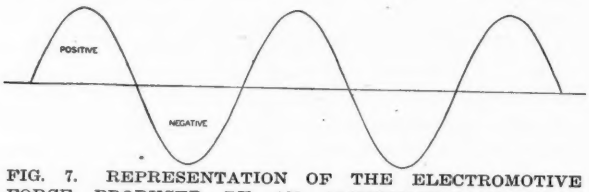


FIG. 7. REPRESENTATION OF THE ELECTROMOTIVE FORCE PRODUCED BY AN ALTERNATING CURRENT GENERATOR

charged and the potential across the spark gap will increase. As the potential rises, a powerful electrostatic field is established between the terminals of the spark gap and finally the air in the gap will break down as described in Part X[5] and become conducting. When this occurs, the condenser will start to discharge across the gap producing damped oscillations.

As the condenser continues to discharge and as the energy is dissipated as heat, the electromotive force due

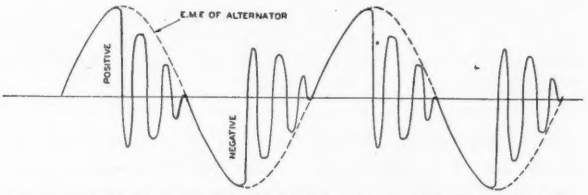


FIG. 8. SUCCESSIVE GROUPS OF OSCILLATIONS PRODUCED BY THE CIRCUIT SHOWN IN FIG. 7

to the charge decreases until, finally, this electromotive force is too small to maintain a current across the spark gap. The gap thus, again, becomes non-conducting and since the generator is still connected to the circuit, the condenser will start to charge immediately. Thus, the process is repeated continuously as long as the alternating-current generator is in operation.

The oscillatory current produced by this arrangement consists of a series of wave trains, or group of oscillations each train of decreasing amplitude, as shown in Fig. 8. The number of wave trains of course depends upon the frequency of the generator electromotive force.

This principle of producing oscillatory currents is extremely important in electrical engineering and it has been of great service in radio work. Its applications will receive further discussion in succeeding articles but, here, we have endeavored to show primarily, how a group of electrons (an electric current) may be made to oscillate back and forth in a circuit so as to produce an alternating electromagnetic field around the conductor.

[5]Part X, Oct. 1, 1928.

# When Is an Engineer Liable on Contracts Signed for His Employer?

*By Leo T. Parker*
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*Cincinnati, Ohio*

IT IS A WELL known fact that improbability of financial loss from a really risky source often detracts to a great extent from the advisability of engineers being protected against occurrences of disaster.

Few engineers underestimate the importance of obtaining insurance against damage by fire, water and wind, yet the chances for loss from this source are not great. Few engineers, however, take the precaution to eliminate the probability of litigation or expensive law suits. Yet it is true that the chances of losses from this source can be greatly reduced by readers becoming familiar with the basic principles of the law closely related to their vocation.

Obviously, attorney fees, the costs of carrying a litigation through three or four courts and a final adverse verdict may easily mean financial loss of many thousands of dollars. Moreover, the records of numerous previously decided lawsuits prove beyond a doubt that a great majority of these controversies may have been prevented had the litigants been familiar with the elementary principles of the point of the law involved.

In order that engineers may have at hand a dependable reference from which to determine broadly the circumstances under which an employe may be personally liable for acts performed while in his employer's service, I have formulated the rule, based upon leading higher court decisions, as follows:

An engineer is personally liable, (1) where he makes a false written or oral statement or representation of his authority with intent to deceive a person who transacts business with his employer; (2) where he knowingly makes a false statement or representation, without intent to deceive, he is liable to both his employer and the other party who sustains loss or a result of the deceit; (3) where he does a damaging act believing he has authority, but actually has none; (4) where he performs unlawful acts on authority from his employer; (5) where he willfully performs a damaging act; and (6) where he knowingly performs acts outside his scope of authority, intending to render his employer a valuable service, and where such acts accidentally effect damage.

### Danger of Affixing Signature

A common source of litigation is where an engineer affixes his signature intending to bind his employer, when in fact he binds himself personally on the contract or agreement. Also, in other instances, an engineer may perform acts or sign instruments resulting in loss to his employer who may hold the former personally responsible for the loss sustained.

In fact, there are many circumstances under which an employe is personally liable for affixing his signature. Sometimes his employer is liable, also. But, as a general rule, the employer is relieved of liability where his employe exceeds the authority and performs acts outside the scope of the employment. Legally an engineer is an agent of his employer. It has been held that the legal reason an agent is personally liable for damages effected, when he exceeds his authority, is because the damaged party is deprived of any remedy except from the employe, since there is no valid contract relation between the employer and the party seeking relief.

For illustration, in the leading case of Kroeger v. Pitcairn, 101 Pa. 311, the Court said:

"The reason why an agent is liable in damages to the person with whom he contracts when he exceeds his authority, is that the party dealing with him is deprived of any remedy upon the contract against the principal, which is not his in fact, and it is but just and fair that the loss, occasioned by there being no valid contract with him, should be borne by the agent who contracted for him with authority."

### Employer's Name in Contract May Transfer Liability

Probably, however, a review of the leading cases on the subject of affixing signatures to contracts will convey the information desired more readily than mere explanation.

The records of the leading case of Edward Collins v. Buckeye Co., 17 O. S. 215, disclosed that a contract was signed "Ed. F. Collins, Agent." Although testimony was introduced to prove that in signing the paper Collins acted solely for his employer, the Court held Collins personally liable primarily because the employer's name did not appear in the body of the contract.

It is interesting to observe that, in explaining the legal reason Collins was personally liable, notwithstanding the testimony that he signed the contract by the instructions of his employer, the Court said:

"In the present case Collins not only failed to disclose the name of his principal . . . but he used words which impart a personal engagement—namely, "I promise . . .,' and signed with his own signature, only . . . The name of the principal nowhere appears and the operative words, 'I promise' are utterly inappropriate to charge the principal. Without the word 'Agent' they are plainly and indirectly the appropriate

language of Ed. F. Collins. With the word added, they are admittedly still his, unless changed by parol proof. Is it competent to show by such proof that the parties intended the simple word 'Agent,' to change the whole tenor of the contract? If the word 'Agent' and the words 'I promise' can be made to harmonize, they stand as the party wrote them. Such is the well known rule. And there is no trouble in so harmonizing them."

Therefore, it is quite apparent that where an engineer signs a contract or agreement as agent for his employer, the content of the body of the contract is considered by the court in determining whether the agent is liable. In other words, a court will not permit evidence to be introduced for the purpose of proving that the agent acted for the employer when signing the paper. Such information must be obtained from the instrument itself, and proof of it will not relieve the employe, under all circumstances, of liability.

### Form of Signature Places Liability

For illustration, in a United States Court litigation, Gill v. General Electric Co., 129 F. 350, it was shown that a contract was signed, as follows:

"Gill and Company
"By Sydney S. Gill,
"W. B. Gill,
"T. Harvey Gill."

Gill and Company consisted of the two partners, Sydney S. Gill and T. Harvey Gill. W. B. Gill was not a member of the firm. Later litigation developed and the Court held all of the signers liable, although it was proved that W. B. Gill was merely a hired employe.

In this case although W. B. Gill was not a member of the firm, the word "By" appeared opposite only to Sydney S. Gill's name. The court explained that if the word "By" had also appeared adjoining W. B. Gill's name, the latter would not have been liable. In reference to this phase of the law, the court said:

"Looking only at the signatures of the acceptance, we concur in the opinion that the word 'By' after the partnership name applies to Sydney, and to him alone."

The Court explained its reason in holding W. B. Gill personally responsible, and said further:

"It is true, that he (W. B. Gill) was not a partner in the firm of Gill and Company . . . but it is also true that he united with the members of that firm in accepting it. The paper which he signed is unambiguous and explicit, and it is impossible to ascribe any other significance to his signature. It must, therefore, be assumed that the mutual understanding that all those who had executed the acceptance would be bound by it.

"The fact that Sydney S. Gill and T. Harvey Gill constituted the firm of Gill and Company is unimportant. As between themselves, these two may have regarded the transaction as a partnership one."

### Significance of Word Agent in Signature

In still another case, Campbell v. Porter, 61 N. Y. S. 712, the litigation involved a contract signed "John A. Porter, Agent." In this instance, also, the court explained that where a person signs a contract, or other paper, by affixing his own name with simply the word "agent" added, such a contract is the signer's own for which he is personally responsible.

In holding Porter personally liable, the court said: "He (Porter) contends that he was merely the agent of another person . . . who he asserts was the real contractor. He signed the contract as 'John G. Porter, Agent.'"

On the other hand, it has been held in (17 Ind. 296) that where the complaining party to a contract knows when the agent signed it that the act was for his employer, and further that the employer's name appears in the body of the contract, the agent is not personally liable although he omits signing the name of his employer in conjunction with his own name.

For illustration, in a leading case (56 Ky. 490) a contract was signed "George W. Williams, G. W. P." The letters G. W. P. were initials of the name of the company which employed Williams. The court held Williams not personally responsible and explained that an employe of a corporation or company, while acting in the capacity of agent, is not individually bound if his signature is applied to an instrument which is in such form that the other party knew he was acting for his employer. The court also said that although the three letters were used to abbreviate the name of the company Williams represented, the fact that, at the time the paper was signed, the complaining party to the contract knew that Williams was acting as agent was a material issue of the case.

### Signing for Employer Without Authority

Of course, an engineer always is personally liable where he signs a paper for his employer who has given no authority to affix his name in this manner.

For instance, in another leading case (24 Mo. 524), a due bill comprised the following form:

"Due, Flat River Mines, September 7th, 1854, Daniel P. Coffman, twenty-seven dollars and 15 cents. (Signed) A. W. Harrison, Agent for Miss. Mining & Manufacturing Co."

When the company refused to pay the amount, Coffman sued Harrison, the agent, who failed to introduce testimony to prove that he had authority to act as agent for the mining company. The court held Harrison personally liable, and explained the law, as follows:

"If he (agent) had authority to bind the company, and did only bind it, he is not liable. If he had not authority to bind the company, the instrument was drawn in a form which would bind himself."

Sometimes, an employer authorizes his employe to sign a contract in the latter's own name. Under these circumstances, both the agent and the employer are liable provided it is proved that the agent had authority to sign his own name without the name of employer.

For instance, in Huntington v. Knox, 7 Cush. 371, it is interesting to note that the court, in effect, said:

"Where an agent, who has contracted in his own name, for the benefit, and by the authority of his employer, seeks to discharge himself from liability, on the ground that he contracted in the capacity of an agent, the doctrine proceeds on the ground that the principal and agent may each be bound; the agent, because by his contract and promise he has expressly bound himself; and the principal, because it was a contract made by his authority for his account."

On the other hand, an employer may sue on a contract made by authority of his agent, although only the agent's name appears on the contract.

In fact, it is a well established rule of the law, both in England and in this country, that where a contract contains only the name of an agent, the latter's employer may maintain a legal action on it in his own name . . . Although the employer is privileged to sue on the contract, however, the agent is personally responsible if the employer fails to fulfill its terms with the other contracting party. (259 Mo. 499)

PRESENT LAW RELIEVING AGENT'S RESPONSIBILITY

At present the law is well established that an employe is relieved of all risk of personal liability on contracts, or other papers which he signs with proper authority provided: (1) the name of his employer appears in the body of the contract, or on the letter head; (2) the word "by" or "per" precedes his signature; (3) the word "agent" or "manager" follows his signature; (4) and the employer's name precedes the agent's signature, as follows:

"The Standard Company,
"By John Doe, Engineer."

Sometimes the mere difference between the words "By," "For," and "Of" is sufficiently important to have considerable bearing on the outcome of the liability of an agent who signs contracts especially if the signature is not affixed in this suggested form. Generally, however, the word "By" should be used.

This point is thoroughly considered by the court in the case of Tucker Mfg. Co. v. Fairbanks, 98 Mass. 101. Here the contract was signed as follows: "David Fairbanks & Co., Agts. of Piscataqua F. & M. Ins. Co."

In this case, the name of the employer did not appear in the body of the contract. This court held the agent personally liable, and said:

"The variation between the words 'for' and 'of' seems at first view slight; but in connection in which they are used in signatures of this kind, the difference is substantial. 'Agent of' a corporation named simply designates a personal relation of the individual to the corporation. 'Agent for' a particular person or corporation may designate either the general relation which the person signing has to another party, or that the act in question is done in behalf of, or as the very contract of that other; and the court may construe the words in the latter sense."

In still another case (16 Mass. 461), an employe signed a contract "Joseph Talbot, agent for David Perry." In this case, the court held the agent *not* liable, and explained the reason for the decision, saying:

"The important and effective word was not the word 'agent' not the name of the principal, *but the connecting word 'for,'* which might indeed indicate merely the relation which the agent held to the principal; but which was equally apt to express the fact that the act was done in behalf of the principal."

# Capacity of Steam Radiator Supply Branches

LABORATORY INVESTIGATION SHOWS RELATIONS BETWEEN SIZE, CAPACITY AND PITCH FOR ONE-PIPE AND TWO-PIPE SYSTEMS. BY F. C. HOUGHTEN, M. E. O'CONNELL, CARL GUTBERLET*

STUDY OF THE CAPACITY of pipe for various parts of a steam heating system has been under way at the A. S. H. & V. E. Research Laboratory since 1922 and the following data result from a coöperative study by the Society and the Heating and Ventilating Department of the Carnegie Institute of Technology. A number of reports bearing on various phases of the subject have been published from time to time including a complete and final report on the subject of capacity of upfeed steam heating risers for one and two-pipe steam heating systems. This paper deals with the results of a study of capacity of radiator supply branches for one and two-pipe systems and gives final results on this phase of the study.

A number of variable factors enter into the capacity of radiator supply branches, all of which must be taken into account in making an analysis of the subject. A typical radiator supply branch from a supply riser is shown in Fig. 1. Its capacity is affected by the pipe fittings C to D and E to G, by the capacity of the vertical section of the branch FG, by the valve G and by the pitch of the main section of the branch DE. The steam carrying capacity of the branch further depends upon whether the condensation from the radiator returns through this branch (one-pipe system) or through a separate return (two-pipe system). To get a clear understanding of the operation of such a branch, it was necessary to make an independent study of each of these factors.

*From a paper presented at the Semi-annual Meeting, A. S. H. & V. E., Ontario, June, 1929.

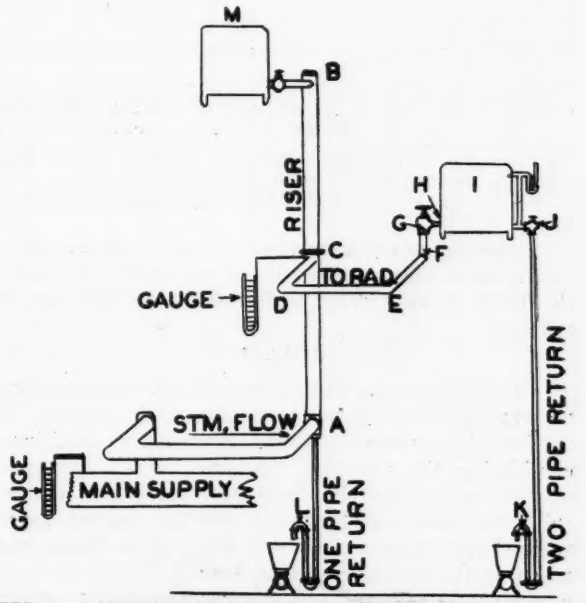



FIG. 1. LABORATORY SET-UP FOR STUDYING RADIATOR BRANCHES

Figure 1 is the laboratory set-up on which the study branches to radiator was made. Steam was taken from the 8-in. main, through the 6-in. branch to the 4-in. supply riser AB. The radiator supply branch CH on which the study was made supplied steam to a cast

iron radiator or water cooled condenser I, located on a movable platform so that the length and pitch of DE could be changed. When the branch was operated as a one-pipe system, J was closed and the condensate returned through the radiator supply branch and riser and collected and weighed at L. When operating as a two-pipe system, J was opened and the condensate from the radiator was returned through the return riser and weighed at K.

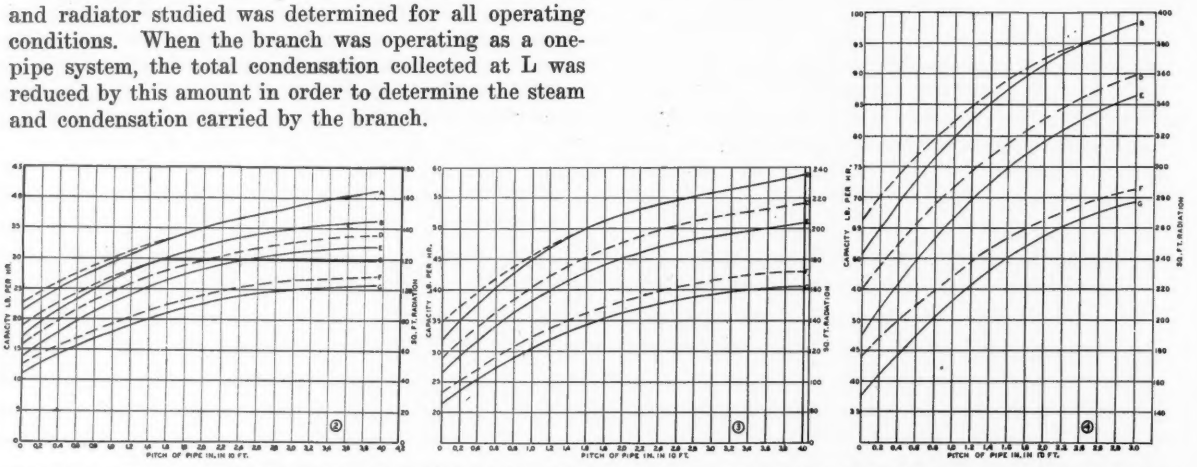
To observe any effect which steam passing on up the riser beyond C had on the operation of the branch and radiator under study, a second radiator or condenser M, was supplied with steam during a part of the study. It was soon found that steam passing up the riser beyond C did not affect the operation of the branch CH unless the riser AC was loaded beyond the maximum capacity recommended for use in an earlier laboratory study. After this fact was established, the riser was cut beyond C and capped.

Condensation in the system other than the branch and radiator studied was determined for all operating conditions. When the branch was operating as a one-pipe system, the total condensation collected at L was reduced by this amount in order to determine the steam and condensation carried by the branch.

in. pipe. Another series of data was collected in which the radiator connection was the same except that the 1¼-in. valve was replaced by a 1¼-in. ell. It was later shown that the same increase in capacity could be had by drilling out the seat of the valve to a diameter equal to that of the same nominal size pipe or by replacing the valve by one of the next larger size.

Data were obtained on a similar branch with 1½-in. fittings replacing the 1¼-in. fittings at CD and EG, Fig. 1. It was further shown that replacing the fittings at either CD or EG alone with the large size gave the same curves as B. Hence it is clear that the capacity shown by C, B, and A in Fig. 2 (which is only one of several groups of curves plotted) are, respectively, the limiting capacities of the horizontal branch alone, the fittings and the valve, of the same nominal size.

Comparison of curves shows that the maximum capacity of the valve was equal to that of the branch with a pitch of 1.58 in. in 10 ft. For greater pitches



FIGS. 2-4. TYPICAL CURVES PLOTTED FROM DATA. SOLID LINES, 10-FT. BRANCH; BROKEN LINES, 5-FT. BRANCH. CURVES A, B AND C IN EACH CASE, MAXIMUM CAPACITIES WITH NOISE; D AND E, MAXIMUM CAPACITIES WITHOUT NOISE; F AND G, 80 PER CENT OF MAXIMUM CAPACITY WITHOUT NOISE

Fig. 2—One-pipe branch: A, no valve, 1½-in. fittings, 1¼-in. pipe; B, no valve, fittings and pipe 1¼-in. nominal size; C, valve, fittings and pipe 1¼-in. nominal. Fig. 3—Two pipe branch; curve B, no valve, fittings and pipe 1½-in. Fig. 4—Two-pipe branch; curve B, no valve, fittings and pipe 2-in. nominal size.

Steam pressures were observed in the main, riser, and radiator and a water column was provided to give the level of any water which might be held up in radiator.

## Results

In attacking the problem, the relation between steam pressure in the main or the riser and the capacity of the branch as a whole, for any given set of conditions, considering the variables mentioned, was determined and the results plotted. In further analysis of the results, the maximum capacity, or the highest point reached on any particular curve for a given branch was taken as the capacity of that branch. Data for such a curve were collected and the curve plotted to obtain this maximum point for each of the many variable conditions on which information was desired.

The valve used in the branch giving the above results was a standard 1¼-in. angle valve. It was found that this valve and, in fact, most valves studied, had a seat opening just 1¼ in. in diameter instead of 1.38 in. in diameter, the actual internal diameter of nominal 1¼ of the main section of the branch the valve restricted the flow, whereas for smaller pitches the section DE of the branch limited the flow.

## Data Were Obtained for 10-Ft. and 5-Ft. Branches

Data just referred to are all for a 10-ft. branch with one-pipe connection (that is, for a branch where the condensation from the radiator returns through the supply branch) and they were collected on a set-up where a water-cooled condenser was used to condense the steam, rather than a radiator. With this set-up, small noises due to overloaded branches could not be detected easily because of the noise of the water flowing through the condenser, also because the small steam condensing space of the condenser did not seem to give the same reverberation to the sound as was experienced with a standard cast iron radiator. Curves D and E, Fig. 4, give the maximum capacities obtainable with steam condensed in a cast-iron column radiator instead of the water-cooled condenser and with the system operating without audible sound.

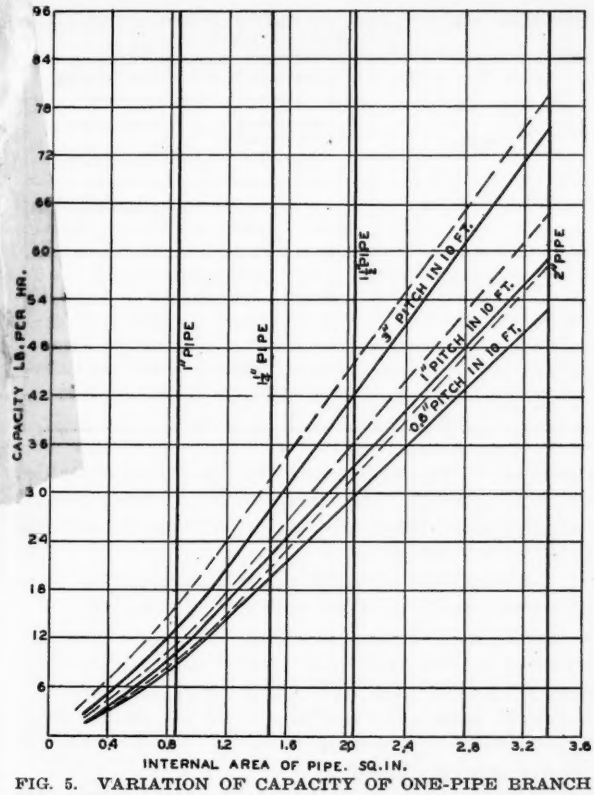



FIG. 5. VARIATION OF CAPACITY OF ONE-PIPE BRANCH WITH PIPE AREA, LENGTH AND PITCH. NO NOISE. SOLID LINES, 10 FT., BROKEN LINES, 5 FT.

For a two-pipe radiator connection (that is, with the condensation returning from the radiator through a separate return branch and riser) there is no difference between maximum capacity obtainable with a valve of the same nominal diameter as the pipe. This is accounted for by the fact that in the two-pipe connection of the type shown in Fig. 1, no condensation returns through the valve. All the steam that condenses beyond the valve returns through the radiator while that condensing below the valve returns through the supply branch and riser. In this system, a valve with a small seat will not result in noise unless it is purely a hissing sound due to the velocity of steam through the valve. A small valve, however, will require a higher steam pressure for the same capacity. Effect of length of a branch on its capacity was investigated by studying branches 5 ft. and 10 ft. in length. The solid line curves give the capacities of the 10-ft. branches, while the capacities of the 5-ft. branches are given by the broken line curves.

### Variation of Capacity with Length and Pitch

It will be noted that for small pitches the effect of the length of the branch is much more pronounced when the condenser was used or when the sound was not the limiting factor. This may be explained by the fact that part of the head producing flow in the horizontal pipe may be due to piling up of water at the end from which it is flowing, so that the actual diameter of the pipe may be considered to some extent as producing flow of condensate counter to the steam. A perfectly level pipe or one with a small reverse pitch will allow condensate to return, but at a reduced rate.

Figures 5 and 6 show how the maximum capacity of branches without noise varies with pitch, area, and length of pipe in the one and the two-pipe systems, respectively. Other curves were plotted to show how the maximum allowable velocity without noise varies with pitch of branch and pipe area for 5-ft. and 10-ft., one and two-pipe branches.

### Practical Application

The purpose of the study was to make available information concerning the flow of steam and condensate in one and two-pipe radiator branches on which a practical and logical set of pipe sizing tables could be based. This information is given in the curves A to E. In making use of these values, however, it should be borne in mind that they are maximum values which could be obtained on commercial pipe under good laboratory conditions. The pipe was well reamed, was new, clean, and straight; there were no sags in the branches.

These conditions will not always be found in practice; some allowance must be made for them. This allowance will be in the nature of a factor of safety. A factor of safety cannot be established by laboratory test alone but should also take into account other factors depending on installation and operating conditions. These factors can better be supplied from the practical experience of heating engineers.

Curves F and G, Figs. 2, 3 and 4 inclusive, give a suggested capacity of branches of the different sizes studied based upon a factor of safety of 20 per cent. The capacities given by curves F and G are 80 per cent of those given by curves D and E.

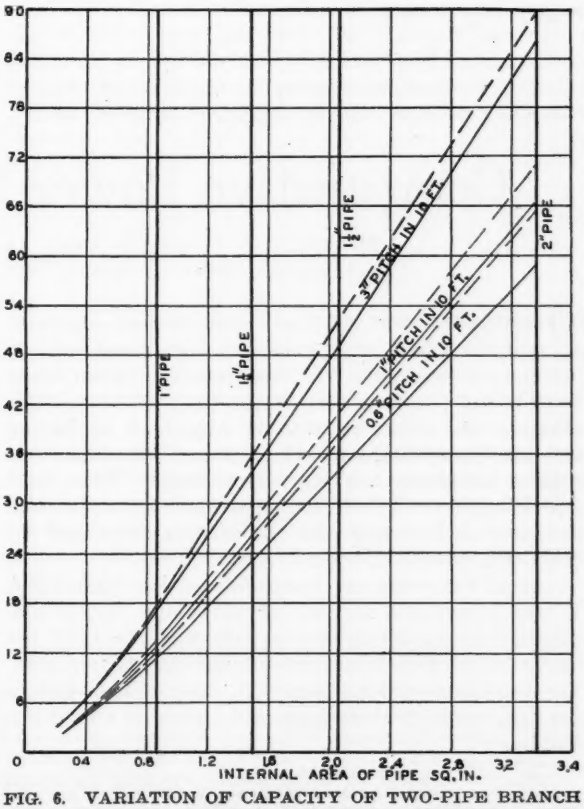



FIG. 6. VARIATION OF CAPACITY OF TWO-PIPE BRANCH WITH PIPE AREA, LENGTH AND PITCH. NO NOISE. SOLID LINES, 10 FT., BROKEN LINES, 5 FT.

TABLE I. CAPACITY OF RADIATOR SUPPLY BRANCHES, ONE-PIPE SYSTEM

| Pipe Size | Capacity in Sq. Ft. of Equivalent Radiation | | | |
|---|---|---|---|---|
| | Based on Curves F and G and pitch of 0.6 in. in 10 ft. | | Based on Guide 1929 Tables 8 and 11, Pitch at least ½ in. in 10 ft. | |
| | 5-ft. Branch | 10-ft. Branch | Shorter than 8-ft. Branch | Longer than 8-ft. Branch |
| *A* | *B* | *C* | *D* | *E* |
| 1 in. | 31 | 28 | 20 | ..... |
| 1¼ in. | 68 | 62 | 55 | 20 |
| 1½ in. | 102 | 93 | 81 | 55 |
| 2 in. | 189 | 169 | 165 | 81 |

TABLE II. CAPACITY OF RADIATOR SUPPLY BRANCHES, TWO-PIPE SYSTEM

| Pipe Size | Capacity in Sq. Ft. of Equivalent Radiation | | | |
|---|---|---|---|---|
| | Based on curves F and G and pitch of 0.6 in. in 10 ft. | | Based on Guide 1929, Tables 9, 10, 12, 13, 14. Pitch at least ½ in. in 10 ft. | |
| | 5-ft. Branch | 10-ft. Branch | Shorter than 8 ft. | Longer than 8 ft. |
| *A* | *B* | *C* | *D* | *E* |
| 1 in. | 36 | 34 | 26 | ..... |
| 1¼ in. | 79 | 75 | 58 | 26 |
| 1½ in. | 117 | 108 | 95 | 58 |
| 2 in. | 209 | 191 | 195 | 95 |

It should be pointed out that values given in the curves are maximum capacities or maximum capacities less a factor of safety as specified. No allowance is made for heating-up load and condensation in either bare or covered pipe. Since these factors vary with other conditions, they should be considered as factors in calculating the maximum demand for steam.

Tables I and II give capacities of one and two-pipe branches, ranging from 1 in. to 2 in. in size as taken from curves F and G, and from The A. S. H. & V. E. Guide, 1929.

The Guide tables specify that branches longer than 8 ft. should be one pipe size larger. Also that branches should have a pitch of at least ½ in. in 10 ft. Capacities in columns B and C in the two tables based upon this study are for a pitch of 0.6 in. in 10 ft. or approximately 1 in. in 16 ft.

### Summary and Conclusions

1. The investigation gives the capacities of one and two-pipe radiator supply branches without audible sound as shown in curves D and E. These capacities are had, however, only when the pipe is well reamed and should be taken with a factor of safety for less perfect workmanship.

2. A series of curves F and G give capacities after a factor of safety of 20 per cent has been applied.

3. Valves found on the market frequently have port openings smaller than pipe of the same nominal pipe size. Such valves limit the capacity of radiator branches below the capacity of the pipe itself for pitches above a certain value, which are, however, greater than the pitches usually allowed.

4. Capacity of a branch is greatly increased by increase in pitch.

5. There is a measurable difference between the capacity of branches 5 and 10 ft. in length; this difference varies with the size of the pipe and the pitch. The larger the pipe the greater the difference in capacity with length. This difference is also more pronounced for small pitches.

# Comparative Power Plant Operating Costs

Comparison of Steam, Electric and Diesel Motive Powers for Pumping Plants and of Four Different Types of Pump Drives.* By A. D. Couch†

PROBABLY WE ARE all more or less convinced that the Diesel engine shows a high degree of efficiency and economy. To illustrate this point more forcibly and put the matter upon a quantitative basis, an example was chosen illustrating a problem of buying new machinery either to extend present capacity or to replace machinery no longer economical. When such a problem presents itself, a comparison is set up between the costs of operating with the existing plant and the calculated costs with other forms of power.

About two years ago, comparison of this kind, Table I, was formulated for one of our plants which contained three horizontal tubular boilers of about 125 hp. each and two horizontal duplex triple-expansion pumps. The equipment had an output of three million gallons per day, was in good condition and housed in a beautiful building.

With the exception of the last column, the data of which could not be obtained until the Diesel plant had been operated, the figures tabulated are actual amounts obtained at the time this study was made. The first column was arrived at by averaging the costs of the last five years of steam operation. In this case, the total operating costs amounted to approximately $29,000. The first cost of this plant is not shown because a 20-yr.-old cost would not be enlightening today; nor would the same equipment be installed in a new steam plant.

### Estimated Cost with Motor Drives

Second column represents an estimate of the operating costs that would be expected, if motor driven centrifugal pumps were installed and power purchased at two cents per kw-hr., the best rate then obtainable. Yearly operating cost would then be approximately $28,760 as against $29,000 for the existing steam plant. Clearly, there would be no advantage in making this change. Of course, it should be borne in mind that the

*Abstract of paper on Diesel Engine Pumping Equipment presented at meeting of New England Water Works Association, Portland, Maine, September 18, 1929.

†Mechanical Engineer, Community Water Service Co., New York.

cost of current may be materially cheaper for some localities than for this particular property. It will be seen, however, that purchased power, in order to beat the final figure in the last column, would have to be bought at approximately 1.1c per kw-hr. The third column represents an estimate for the Diesel installation showing a total operating cost of $16,730 or an operating saving, over the existing steam plant, of over $12,000 a year.

### Estimated Costs with Diesel Equipment

On a basis of 15 per cent fixed charges per year, a Diesel engine plant costing $80,000 could be justified, retaining the old steam plant for standby purpose only. Actually, the Diesel plant cost approximately $43,000, which is $500 less than the estimated cost. Adding 15 per cent of this first cost to the yearly operating cost, a total cost of $23,255 was estimated for the engine plant. This figure compares with $29,825 fixed and operating costs for a motor-driven plant with purchased power. In comparisons of pumping plants, all figures are reduced to cost per million foot-pounds pumped. On this basis, the fixed charges plus operating costs of the electric plant amount to $0.01343; while for the Diesel plant this combined cost is $0.01048. Although no fixed charges for the steam plant have been shown, it is readily seen that, even with the steam plant costing nothing to build, the Diesel plant would still represent the best investment. It was, therefore, decided to install a 338-hp. Diesel engine arranged to drive a three million gallon per day centrifugal pump through a 400-hp. step-up gear. The complete installation also included a 25-kw. generator, connected to the pump shaft, to generate current for lights, low lift pumps and other auxiliary power plant requirements.

### Actual Diesel Costs Less Than Estimate

Actual costs of the Diesel installation are given in the last column of figures. These figures cover the first year's operation. It will be noted that the total operating cost was $13,798 as against the estimated figure of $16,730, representing a further saving of almost $3000. This is reflected again in the fixed charges plus operating cost per million foot-pounds, which was $0.00822. One reason for the lower total cost was the increased output which was more than one hundred million gallons over that estimated.

TABLE I. YEARLY UNIT POWER COSTS OF STEAM, ELECTRIC AND DIESEL DRIVEN PLANTS OF COMMUNITY WATER SERVICE CO.

| Item | Yearly Cost | | | |
|---|---|---|---|---|
| | Steam* | Electric** | Diesel** | Diesel*** |
| No.1 Coal, 6.50 per t. | $ 12,869. | $ 360. | $ 360. | $ 302. |
| No.2 Power, 2¢ per kw-hr. | | 22,200. | | |
| No.3 Fuel Oil, 6.7¢ per gal. | | | 7,350. | 7,034. |
| No.4 Lubrication | 800. | | 480. | 496. |
| No.5 Engine Repair | 1,000. (Includes Boilers & Aux.) | | 400. | 172. |
| No.6 Pump Repair | (Included above) | 200. | 150. | |
| No.7 Labor | 13,275. | 6,000. | 7,800. | 5,396. |
| No.8 Supplies | 1,000. | | 250. | 398. |
| No.9 Operating Total | 28,944. | 28,760.## | 16,730.## | 13,798.### |
| No.10 First Cost# | | 7,100. | 43,500. | 43,000. |
| No.11 Fixed Chgs.-15% | | 1,065. | 6,525. | 6,450. |
| No.12 Oper.+ Fixed | | 29,825. | 23,255. | 20,248. |
| No.13 Million Gallons | 800 | 800 | 800. | 925 |
| No.14 Aver.Ft. Head | 335 | 335 | 335 | 309 |
| No.15 Million Ft. Lb. | 2,220,000 | 2,220,000## | 2,220,000## | 2,462,044### |
| No.16 Oper.Cost/M.F.P. | $ 0.01304 | $ 0.01295 | $0.007540 | $ 00.00560 |
| No.17 Oper.+ Fixed/M.F.P. | | $ 0.01343 | $0.010480 | $ 00.00822 |

*Average, Five Years; ** Estimated; ***Actual
#Less Building; ## Without Aux. & Light Power; ###With Generator Included

TABLE II. COST COMPARISON OF DIFFERENT TYPES OF PUMP DRIVES AND ARRANGEMENTS

| | Plant No.1 | Plant No.2 | Plant No.3 | Plant No.4 |
|---|---|---|---|---|
| Kind of Plant | Pump Geared Centrifugal | Pump Geared Triplex | Elec.Gen & Motor Cent. | Air Lift & Triplex Air Lift |
| Type of Pump-Low Lift | None | None | Cent. | Triplex |
| -High Lift | Cent. | Triplex | Elec. | Dir.Connect. |
| Pump Drive-Low Lift | None | None | Elec. | Belted |
| -High Lift | Stepup Gear | Stepdown | 2-360 | 1-60 |
| No. of Engines & H.P. | 1-338 | 1-40 | 1,900,000 | 125,000 |
| Gal. per Day - Low Lift | | | 35 | 100 |
| Total Head in Ft.-Low Lift | | | 1,860,000 | 125,000 |
| Gal. per Day - High Lift | 2,880,000 | 700,000 | 286 | 248 |
| Total Head in Ft.-High Lift | 307 | 190 | 205 | 148.6 |
| Mil.Ft.Lb.per 100 Lb.Fuel Oil | 324 | 264 | $0.00723 | $0.0242 |
| Oper.Cost per Mil.Ft.Lb. | $0.00515 | | | |

Engine repair cost was estimated at $400 while the actual cost was $172. But repairs to a Diesel engine increase generally year by year up to the 5-yr. period at which the maximum is reached. At this period, considerable maintenance work will be necessary; the engine should then be reconditioned to make it practically as good as new. After this, the cost cycle will return to first year conditions. Therefore the $400 estimated represents, it is believed, a fair average for this 5-yr. cycle.

### Influence of Type of Drive on Operating Costs

Table II shows results obtained in some of the Community Water Service Co. plants in which oil engines are installed. The figures shown were taken from our records for the month of May, 1929. They should serve as a fair example, since the load during this particular month is neither the lightest nor heaviest of the year. Plant No. 1 is the one previously described. Plant No. 2 contains a 40-hp. engine direct connected to a triplex pump. Plant No. 3 has two 360-hp. engines direct connected to generators which supply current for operating motor-driven pumps and plant No. 4 has a 60-hp. engine direct connected to an air compressor which furnishes air to operate the air-lift pumps and which is also belted to a triplex pump for high lift pumping. It will be noted that the direct gear-driven installations are the most efficient while the air lift installation is seen to be the least efficient in this case.

### Comparative Costs

Table III presents the comparative operating costs of three good average Community Water Service Co. plants which are operated by steam, electricity and Diesel power respectively, the last being the Diesel plant previously described. These records were also taken for the month of May, 1929. The steam plant selected contains triple-expansion, Corliss-valve, pumping engines and is located where coal can be delivered in the bins for approximately $3.33 per short ton. The purchased-power plant buys current for approximately 1¼ cents per kw-hr.

TABLE III. AVERAGE OPERATING COSTS OF STEAM, ELECTRIC AND DIESEL DRIVEN PUMPING PLANTS

| | Steam | Purchased Power | DIESEL |
|---|---|---|---|
| Mil. Gal. Per Day | 8.17 | 2.35 | 2.88 |
| Average Head-Ft. | 316 | 341 | See) |
| Mil.Ft.Lb.per Month | 669,887 | 207,485 | Plant) |
| Efficiency-Wire to Water | - | 71.2% | No.1) |
| Coal-Tons per Month | 620 | - | |
| Oper.Cost per Mil.Ft.Lb. | $0.00818 | $0.0063 | $0.00515 |

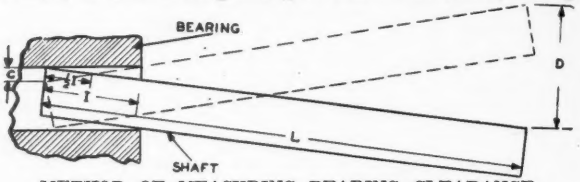
# Measuring Clearance Without a Micrometer

By W. F. Schaphorst

EVERY USER of shafting knows that a loose shaft will wiggle. The looser the shaft the greater the wiggle. In other words, the looser the shaft the greater the clearance.

I dare say, however, that few users of shafts know that this wiggle characteristic may be utilized for determining the amount of clearance between the shaft and its bearing. The sketch shows how it is accomplished and why it is possible to measure clearance in this way.

Take the shaft out of the bearing and measure its length L in inches. Then shove it part way back into the bearing, distance I, which might be called the distance of insertion. Now move the end of the shaft from extreme to extreme the distance D, as shown in the sketch. It is obvious that the distance D is directly proportional to the clearance. The greater the clearance the greater the distance D. If there is no clearance whatever, the end of the shaft cannot be moved. Of course, if it is a long shaft, it can be deflected, owing



METHOD OF MEASURING BEARING CLEARANCE

to the elasticity of the shaft. This matter of deflection must be taken into consideration. If the shaft is short and large in diameter, deflection may be neglected.

After making all of the measurements noted above, as shown on the sketch, multiply the movement distance D by the insertion distance I in inches and divide by the difference between twice the length of the shaft L in inches and the distance of insertion, i.e., 2L — I. The result will be the clearance in inches to within a negligible error.

For those who would rather use a formula than a rule, following is the way in which the rule was worked out mathematically. The error, it will be noted, is proportional to the versed sine of the angle between the axis of the bearing and the shaft in its deflected position.

$$C : \tfrac{1}{2} I :: D : L - \tfrac{1}{2} I$$

whence

$$C\,(L - \tfrac{1}{2} I) = \tfrac{1}{2} DI$$

therefore

$$C = \frac{DI}{2L - I}$$

For example, if D = ½ in.; I = 1 in.; and L = 10 in.; application of the above rule tells us that the clearance between the shaft and bearing is 0.01316 in.

This sketch has been exaggerated purposely, of course, to show the principle governing this method of determining clearance. It is obvious that this method is useful also for determining whether or not a bearing is out of round and, if so, how much. This is accomplished by measuring the distance D in several directions.

# Large Pipe Line Arc Welded

FOR THE Uinta Pipe Line Co.'s line southeast of Rock Springs, Wyoming, to Ogden and Salt Lake City, Utah, the total length when completed, will be 277 mi. Of this, 200 mi. is of 18-in. pipe, the remainder being of 16-in.

Pipe used is of arc welded manufacture produced in 30-ft. lengths having bell and spigot ends with welding dam. Some idea of the nature of the country traversed by this line may be obtained from Fig. 1, which shows a completed portion of the line on a 60 per cent grade.

FIG. 1. PIPE LINE ON A GRADE OF 60 PER CENT

the sections being welded on top of the hill, then lowered into position.

To form a section, a number of lengths is lined up, the number in each section depending upon the contour of the ground. Spigot ends of the pipe lengths are inserted into the bell ends and the entire section thus formed is leveled by shoring or blocking up with timbers, a set of four steel rollers consisting of two pair mounted on a steel channel base being placed on the top shoring timber to facilitate turning the section while welding.

After the pipe is lined up and leveled in sections,

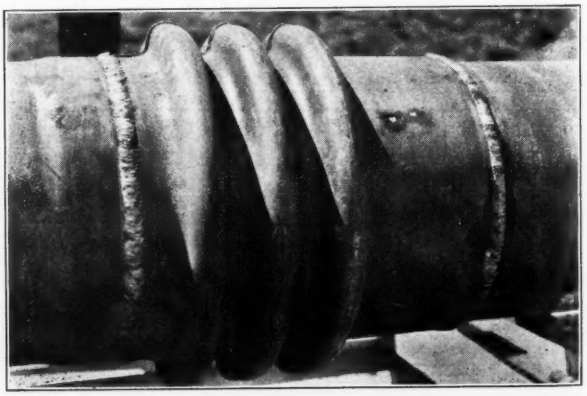


FIG. 2. EXPANSION JOINT USED AND COMPLETED ARC WELDED JOINTS

each joint is tack welded, so that contraction and expansion acts on the section as one unit instead of separate pipe lengths.

Each joint is arc welded twice with two separate beads to prevent all possibility of pin hole leaks. For the first, or burning-in bead, 3/16-in. electrodes are used, approximately ¾ lb. of metal for the burning-in bead in the 18-in. joints. The finish bead is welded with ¼-in. electrodes, approximately 1¾ lb. being consumed in making the finished weld. When welding the pipe lengths into sections, 8 to 12 joints per man per day are being obtained.

After the pipe is welded into a section, the section is placed over the open trench on skids and welded into the line, known as bell hole welding. Being unable to turn the line, the operator must weld around the pipe, necessitating overhead welding. The speed of welding such joints varies from six to eight joints per operator per day.

To take care of the expansion and contraction of the finished line, caused by temperature changes, a special type of expansion joint of all-steel construction is welded into the line at intervals, as in Fig. 2. This pipe line is the first of 18-in. size to be arc welded.

# Surging of High-Speed Hydraulic Turbines

IT IS OFTEN CAUSED BY CONSTRICTION OF WATER INLET OR DISCHARGE PASSAGES, WHICH SHOULD BE ENLARGED OR REDESIGNED. BY H. S. SCHREINER

FOR SOME TIME, we have been thinking that the surging in both rotational speed and voltage and the resultant surge in some high-speed hydraulic turbines was something inherent in the design, that it was to be expected and that little or nothing could be done about it. We also thought that as we got farther away from the more conventional specific speeds of 10 or 15 yr. ago, we should find this surging present in greater degree and that the only thing we could do about it was to tie into a large system so that the swinging was damped out by the rest of the system.

Study of some of the earlier plants that were not entirely satisfactory in this respect has revealed a number of things and after some experimentation, satisfactory cures have been found. One aggravated case was a turbine that was claimed by the maker to be a Francis turbine; it was stated that merely removing the band does not make it a propeller turbine, although the specific speed is about 170. This turbine caused the frequency and voltage to surge so badly that it was almost impossible to keep load on it. The manufacturer designed the setting and showed the sizes of the tailrace and other passages.

After some study of the case, in which the problem was practically given up by the manufacturer as hopeless, someone brought the uncommon talent of common sense to bear upon the situation and decided that the discharge from the turbine was choked. Without further ado, the tailrace was cleaned out so the water had more room to get away without going through a whirlpool rapids. That greatly improved matters. Then the plant operator decided that the draft tube flare was not great enough and prevailed upon the management to order a new draft tube. The net result was that the turbine ran quietly but that the full load power was a few per cent below the guarantee. Then the management, greatly pleased with the result, suggested that they buy another draft tube that had a flare of a mean between the first tube and the second. When this was installed, the power was brought up to guarantee and the quiet running was still secured. The conclusion reached was that one could go too far in flaring the draft tube so that the water broke away from the sides of the steel tube and the draft head was reduced beyond the value for best efficiency.

Another case was that of a turbine set into an old plant where the owners refused to excavate for the proper discharge of water from a turbine developing some 50 per cent more than the capacity of the original unit. The owners also concluded that while the water might make more disturbance in getting away, it would not affect the power seriously. After starting up the new unit, the guarantees of the manufacturer were fulfilled but there was the disagreeable surging in frequency, which always makes synchronizing more difficult. A little later, there was a change in ownership and the plant became part of a base load proposition in a large system.

### ENLARGED WATER PASSAGES FOR LARGER TURBINE REDUCE SURGING

The superintendent who came in saw room for improvement. In this case, excavating was started with a view to greater depth under the tube discharge; when this excavating was completed, far less surging was observed. Later, due to weakened foundations, the unit was shut down and new footings put in under the walls nearby and the tailrace widened about 10 per cent. The net results were 12 per cent more power and extremely quiet operation, much greater ease in synchronizing and everybody greatly pleased. By extremely quiet operation in this case is meant that, whereas the frequency surge was originally two cycles above and below normal, the final result was not more than ½ cycle above and below.

A third case involved a water turbine plant with a restricted tailrace such that the tailwater was running about two feet higher than originally expected, because a ridge of rock downstream formed a sort of submerged weir. Naturally, the expected power of the turbines was not realized. Nobody felt like doing anything about it and correspondence was going back and forth between the plant management and the turbine manufacturer in rather sharp language. It seems that the turbine manufacturer's engineer had measured the head when the old turbines were shut down and the ridge of rock did not show its effect. They did not get anywhere until the power company blasted out the ridge; then everything went along finely.

A situation that puzzled the operating force of a sizable system occurred where the room around the tur-

bine casing was limited and a larger turbine had been put in a setting originally designed for a smaller unit. This was a case of throttling or choking of the water before it got to the turbine runner. Up to about 0.6 gate stroke, the efficiency and power were all that the manufacturer guaranteed. From then on, the efficiency and power broke off sharper and sharper, so that, at full gate stroke of the governor, the power was slightly less than at 0.6 stroke. The turbine's effective head went down rapidly the farther the gates were opened. After much study of possible alterations in masonry, the head race was finally increased a third in width and the walls hollowed out an extra two feet at the turbine casing. Thus the turbine manufacturer's guarantee was met, with 5 per cent power to the good and with every indication that the efficiency was obtained. In this case, the controlling factor was that the friction loss suffered by the water in getting through the turbine was more than the gain in power due to opening the gates.

Summarizing the foregoing experiences, it is well to guard against tailrace choking when increasing the output from a given flume, especially with the higher speed wheels, since the velocities in them are higher than was the practice in the older types, in proportion to the head.

Where surging of disagreeable extent is experienced, one may carefully consider the possibilities of tailrace improvement by providing either more room around the draft tube itself, if it is of the straight flared type, by giving a slightly greater flare to the tube itself or by a combination of both. Where the draft tube is of the curved concrete type, it is a somewhat different matter. First the design may be defective, if the tube is over six years old, for since that time great advances have been made in the design of curved elbow tubes so that they are usually equal in performance to other widely used types. Second, the tube may be overloaded. If so, in many cases the substitution of a new tube for the old one will often show handsome profits on the investment.

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FOR THE PURPOSE of comparing engine performance, the Rankine cycle is used. This cycle for a perfect engine consists of a constant pressure line from admission to cutoff; then adiabatic expansion of the steam, (that is, without any heat loss through the cylinder walls) to the exhaust pressure; exhaust at constant pressure and a vertical compression line up to the point of admission.

In practice, this cycle is not possible; due to wiredrawing, the admission line drops; because of radiation and condensation the expansion line is lower than the ideal; because of excessive costs of large cylinders, the toe of the diagram must be cut off; losses in the ports and exhaust passages raise the back pressure line and cushioning of the reciprocating parts makes compression necessary, thus further reducing the area of the pressure volume diagram.

Comparing the efficiency of the actual engine with the ideal engine gives a value known as the Rankine cycle ratio and this ratio tells how closely the actual engine approached the performance of the ideal engine. This ratio will run from 50 to 90 per cent, depending upon the size, type and condition of the engine.

# High-Voltage Underground Cable for Westchester

RAPID GROWTH of Westchester County, just north of New York City, is causing a greater demand for electric light and power in the Westchester area. To give added security of service, a second 12-mi., 132,000-v. underground cable line that will carry approximately 100,000 kw., is being installed between the Hell Gate generating station of the United Electric Light & Power Co., in the Bronx, and the Dunwoodie distributing station of the Yonkers Electric Light & Power Co. This cable is the same type cable as the first, which was installed about 2 yr. The first one has been in continuous operation since August, 1927, without a break in service, and it is expected to be supplemented by the new cable this fall. Through interconnection between the generating plants of the several companies in the system, it is possible for Westchester, should the need ever arise, to draw power from Manhattan or even from Brooklyn.

From operating the older cable, certain experiences have been gained, which resulted in a number of improvements and refinements in the new cable. The older cable made use of what was then a new invention, which at one step doubled the operating voltage for underground transmission. This consisted in filling the hollow core with oil under pressure. But the cable had to be shipped from the factory with the oil drained off, and had to be refilled after installation. This, of course, was a lengthy process requiring great care. Now the new cable lengths are shipped from the Schenectady plant of the General Electric Co. with the core filled with oil supplied by temporary reservoirs mounted inside the cable reels. The jointing is done under oil pressure with the temporary reservoirs connected to the opposite ends and is accomplished with little loss of oil.

In the first cable, the permanent oil reservoirs were placed about one mile apart and the maximum oil pressure on the cable was approximately 30 lb. In the new cable, the oil reservoirs are placed about three to the mile and the maximum pressure is about 16 lb. Of course the result of this decreased pressure has been a reduction in the amount of sheathing necessary. The first cable has a double sheathing. The inner layer of lead is reënforced by a spiral wrap of copper tape to give the strength necessary to withstand the oil pressure, over this is a second layer of lead to protect the copper tape from abrasion and corrosion. In the new cable, the copper binder and outer lead sheath are not necessary since the oil pressure is cut in half.

In delivering the cable reels from the factory, much needless trucking has been eliminated. Instead of trucking the cable reels from the factory to the cable storage yard and holding them there till needed and then retrucking them to the place of installation, a new plan has been devised. Deliveries are made to freight yards nearest to the points of installation and the reels, when needed, are trucked only once—directly to the job. An accurate schedule has been worked out, so that all cable is pulled in within 24 hr. and much of it goes in the day of delivery.

## Storage Pile Computation

REFERRING to Paul F. Rogers' valuable contribution to the August 1, 1929 issue entitled Calculating Tonnage of Coal in Storage Piles, the writer has developed and successfully used a similar method which he believes is somewhat simpler than that of Mr. Rogers.

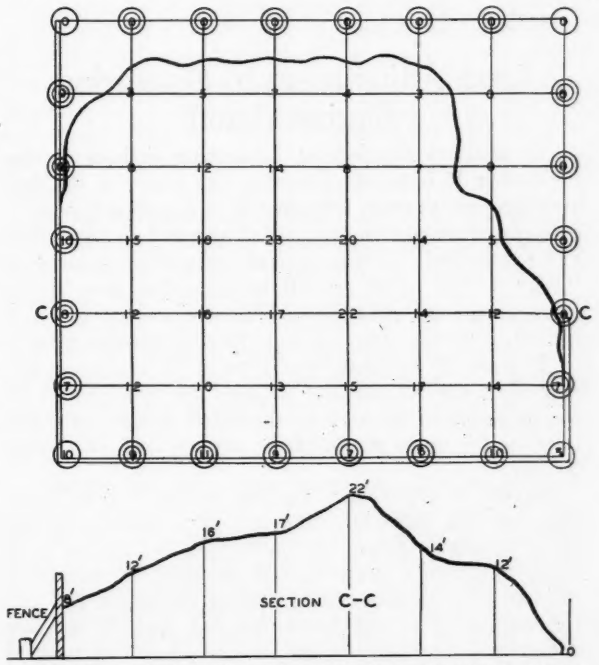
Like that one, the method used by the writer is based on volumetric measurements which are more reliable indications of the mass of small sizes of coal, than weight. The weight of a given quantity of coal will vary widely with atmospheric conditions and weight means little unless a careful correction is made for surface moisture. The volume, however, remains constant, for all practical purposes.

Essentially, the writer's method is a modification of the method used by surveyors in determining the amount of earth excavation and fill in railroad construction. It consists of dividing the horizontal projection of the coal pile into equal spaces, say 10 ft. by 10 ft. and measuring the elevation of the four corners of each space. The sum of the four elevations divided by 4 gives the average elevation of the given space, which, multiplied by the area of the space, gives the cubical contents of the coal in that space. The sum of the cubical contents of the individual spaces is equal to the cubical contents of the pile, which multiplied by the specific weight of the dried coal, gives the tonnage of dry coal in the pile.

In the illustration, coal is piled up against a fence along part of three of its sides. The numbers in the corners of the various 10-ft. square spaces, represent elevations in feet above ground level. If the ground is not level, suitable correction must be made and elevations recorded in terms equivalent to those for level ground. Elevations at the 10-ft. intervals may be determined by means of an engineer's level or stadia transit or by means of a 10-ft. erector's leveling board, plumb-bob and 6-ft. rule.

It is evident from the diagram that work of computing the volume of the pile may be simplified by adding together the elevations of the four corners of the field, shown in circles in diagram, and twice the sum of all the elevations designated by double circles, along the contour of the field except those at the corners and to this add four times the sum of all of the rest of the elevations. Dividing the sum of all these quantities by four, which will give the equivalent height of a hypothetical column whose base is one square and multiplying by the number of square feet in one of the spaces, which in this case equals 100, will give the volume of the coal pile in cubic feet.

Elevations in the corners of the field are considered only once because they are adjacent to only one space;




METHOD OF BLOCKING OUT STORAGE PILE IN 10-FT. SQUARE UNITS IN PREPARATION FOR COMPUTATION

those along the sides of the field are adjacent to two spaces and all interior elevations are adjacent to four spaces. This formula is so general that it does not matter how far the spaces may be extended beyond the outline of the coal pile base, since elevations beyond the limits of the pile would be zero and the result will be correct.

Applying the formula to the field illustrated, the cubical contents will be 38,675 cu. ft.

Specific weight of the coal may be determined by spreading a representative quantity of the coal in a warm, dry place for about 6 hr., filling a container such as a box having 2 by 2 by 2 ft. inside dimensions and carefully weighing it.

The weight of a 2 by 2 by 2-ft. box of certain dried

coal is 392 lb., which makes the specific weight of the dried coal equal to 49 lb. per cu. ft. The contents of the coal pile will then be approximately $(49 \times 38{,}675) \div 2000 = 950$ short tons. We may also find the specific weight of the coal by first obtaining the weight of a barrel of water at 67 deg. F. which will be, say, 289 lb. and of a barrel of the coal which in the case taken weighed 228 lb. then the specific weight of the coal will be $62.33 \times (228 \div 289) = 49$ lb. per cu. ft. The contents of the coal pile will then be found as before.

To illustrate the gain in time by use of the simplified method, a 10,000-t. coal pile, which would probably occupy a space 300 ft. by 300 ft. in area, would necessitate 900 separate computations by the long method. By means of the simplified method, the contents may be computed in 5 min. with the aid of an adding machine. The two methods will give identical results.

By means of the method described, the writer has determined the contents of 10,000-t. coal piles with the aid of two assistants in about 10 hr. Repeated checks have convinced him that an accuracy of about 2 per cent can easily be attained by those proficient with the method.

Ampere, N. J. E. Ogur.

## Lead Adjustment in Equalizing Engine Cutoff

In reading the several interesting articles in the September 15 issue, my attention was drawn to the first question and answer, referring to a compound vertical condensing marine engine, which appears on page 1032 and particularly to that part of the answer relating to "Why do the valves cut off later on the down stroke than on the up stroke?" While the answer given is correct, I would like, if I may, to add something to it.

It seems to me that the design of the valves or the way they are set are not as good as they should be for, as stated in the answer, the cutoff should not occur later on the down stroke of the pistons than on the up stroke.

Study of either the Bilgram or the Zeuner valve diagram will show that the lap of a slide or piston valve should be greater at the top end of the valve in order to obtain a proper cutoff to offset the weight of the parts, the cross-sectional area of the piston rod and the angularity of the connecting rod, also, to a lesser extent, the angularity of the eccentric rod. In most, if not all, marine engines, the lap of the valves is somewhat greater at the top. For instance, if the bottom lap on a given valve were $\frac{7}{8}$ in., then the top lap would be approximately 1 in., depending on the length of the connecting rod, which has a bearing on the problem, and the other dimensions of the valve, as well as the cylinder steam and exhaust ports.

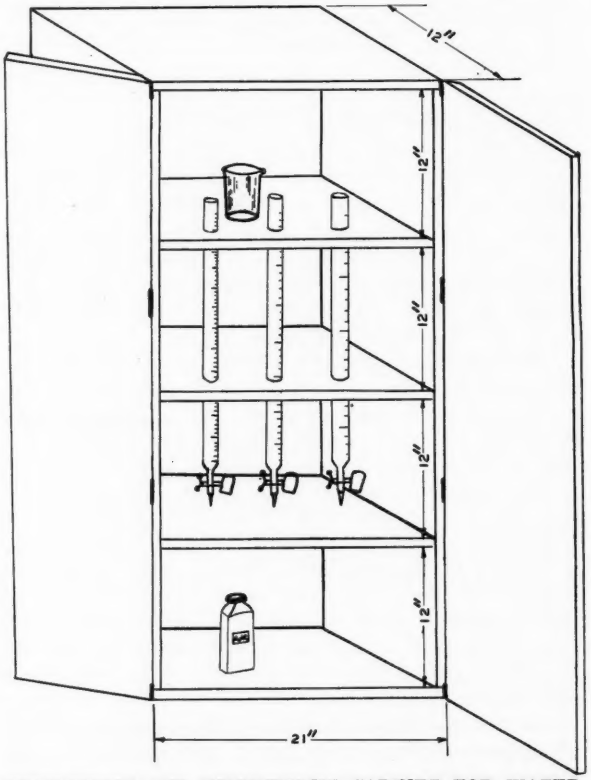
If the valves of the engine in question are designed with top laps greater than those at the bottom, then it seems to me they are not correctly set, either with regard to their position on the valve stems or in relation to the angle of advance given to the eccentrics. The leads of both valves at the top, $\frac{1}{4}$ in. and $\frac{5}{16}$ in. respectively, are too much for that size engine and I believe that employment of no positive lead at all, that is a line and line condition, would produce better results for the entire engine. Little if any lead, however, is required at the top ends for the reasons that have been given in the answer to the question.

There is too little data given in the question or the Bilgram or Zeuner diagram could be applied to determine what the laps should be in order to obtain reasonable cutoffs for both top and bottom strokes. In addition to the data already given, the travel of the valves and the length of the engine connecting rods should be known. It would be interesting to hear the opinions of other readers on this question and what is involved in its answer.

Brooklyn, N. Y. Charles J. Mason.

## Boiler Water Testing Equipment

Every plant engineer should know the total alkalinity of the boiler feedwater and the boiler water. He should know the different kinds of alkalinity and the amount and total hardness of each as well as the amount of concentration of chlorides in the boiler.




CONVENIENT AND INEXPENSIVE CABINET FOR WATER TESTING APPARATUS

To obtain this information is comparatively simple and reasonable accuracy can be secured by the average operator if he has proper equipment such as listed below:

3—25-c.c. glass burettes, measuring in tenths; 3—4 by $\frac{1}{8}$-in. rubber hose nipples; 3—steel clips; 3—$\frac{1}{8}$-in. glass nozzles; 1—150-c.c. evaporating dish; 1—measuring glass marked 58.3 c.c. and 29.15 c.c.; 1 glass stirring rod; 1—8-oz. shaker bottle; 1—small glass funnel; 1—package of filter paper; 3—small dropper bottles; 4-oz. phenolphthalein indicator; 4-oz. methyl-orange indicator; 8-oz. potassium-chromate indicator, $K_2 Cr O_4$; 1 qt. standard soap solution, 1 c.c. = 0.001 $CaCO_3$; 1 qt.

sulphuric acid, N/50, $H_2SO_4$; 1 qt. silver-nitrate solution N/50 Ag $NO_3$; 3—Small graduate glasses: 1—bulb syringe with glass nozzle 4 in. long.

This equipment should be kept clean, neat and in a convenient place such as a cabinet indicated in the accompanying figure. This cabinet is easily made of ⅛-in. lumber. Two coats of gray paint on the outside and white paint on the inside will enhance its appearance. The arrangement of the cabinet consists of three shelves and four compartments. The lower compartment should be used as storage for stock; the first shelf for the evaporating dish, stirring rod, measuring glass and shaker bottle; the second shelf for dropper bottles; filter paper and funnel and the top shelf for the graduate glasses. These glasses should be labeled and always filled with the same solution. Each burette also should be filled with the same solution. If a mistake is made, the glass or burette should be rinsed with the solution intended for it and that rinsing solution thrown away.

Silver nitrate should be kept in a colored bottle as light deteriorates the solution. A pint fruit jar with a piece of 16-gage wire twisted around the neck for a handle may be used for drawing a sample of water from a water column. For each boiler, there should be a jar properly marked with a number corresponding to the number of the boiler. This serves as a check against possible error in the report. After each test, each vessel should be cleaned and dried and the equipment arranged in a manner to prevent error.

Anderson, Ind. GEORGE S. BILLMAN.

## Waste at Drips Represents a Financial Loss

CONDENSATE is the best kind of boiler feedwater because it has already been distilled in the boiler and carries no impurities; at least it should carry no dirt and impurities. If it does, the engineer should make it a point to remedy the condition so as to obtain clean condensate to return to the boilers. It is surprising how many engineers allow all drips and drains to discharge to the sewer, thus not only losing heat but making it necessary to treat additional water and put just that many more grains of solids into the boiler which must be gotten rid of by more frequent blowdown. Four losses occur under this procedure; first, the heat in the condensate; second, the cost of an equivalent amount of treated water; third, heat loss due to the extra blowdown necessary to carry off the increased solids in the boilers and lastly, the cost of the additional amount of blowdown water. Sometimes there is an additional loss due to the extra amount of scale that is deposited in the boiler.

If condensate from drips and drains is all carefully collected around the average plant, it is surprising the difference it makes in the boiler makeup and in the temperature of the feedwater where the amount of exhaust steam is limited. Of course one must be careful to see that the water thus collected is clean and that it has insufficient dissolved air to cause corrosion. The ordinary open heater is a good deaerator and will get rid of most of the air, if the temperature is kept around 210 deg. F.

If the load is uneven, the greatest amount of water will probably come back at a time when the boiler cannot take it, so a storage tank should always be provided, preferably just above the feedwater heater, so that any excess water can be stored and fed to the heater as needed. Many plants have the drains coming back directly to the heater which, filling up, wastes all the excess water through the overflow drain, so that either city water or treated water must be used to make up the deficiency when the load is heavy. Returns should always be brought to a suitable storage tank having ample capacity. If this tank cannot be put over the heater, a float controlled pump may be used to pump the water as needed up to the heater.

Brooklyn, N. Y. P. F. ROGERS.

## When Is a Steam Cylinder Properly Lubricated?

DETERMINATION of whether or not a steam engine cylinder is properly lubricated presented itself as a problem to an engineer friend of mine and he adopted the following plan: When the head of the cylinder was removed, the walls and head of the piston looked well lubricated and were pronounced by the plant engineer to be in excellent condition. My friend took four pieces of white paper and asked the engineer to rub them horizontally on the top, sides and bottom of the cylinder, reaching as far back as possible. These pieces of paper then were marked "Top," "Bottom," "Right Side" and "Left Side" in the order of use. They were also dated.

While the particular cylinder wall or surface seemed well lubricated, little oil appeared on the four pieces of paper, and this was of a rusty color. After the new lubricant had been in use for three weeks, the operation was repeated and the difference in the two sets of papers was found to be so great that the engineer unhesitatingly remarked that he then had 10 times more oil on the cylinder walls than before, notwithstanding the fact that the feed of the lubricator had been cut down to feed one-third as much oil as previously.

Shortly afterward, my friend had occasion to open another steam cylinder. This was of a new engine which had been running only six months. When the head was taken off, the engineer remarked that he could not ask for better lubrication. To my friend, the cylinder seemed well lubricated also but he used the paper test and had the engineer do the rubbing. The paper was applied to the top of the cylinder first and to their amazement the paper showed practically no oil at all. The sides were a little better and there was too much water in the cylinder to make the test on the bottom. They then repeated the test and the papers came out almost entirely free of oil. The engineer remarked that he was glad he had made the test as it convinced him that the cylinder was not being properly lubricated.

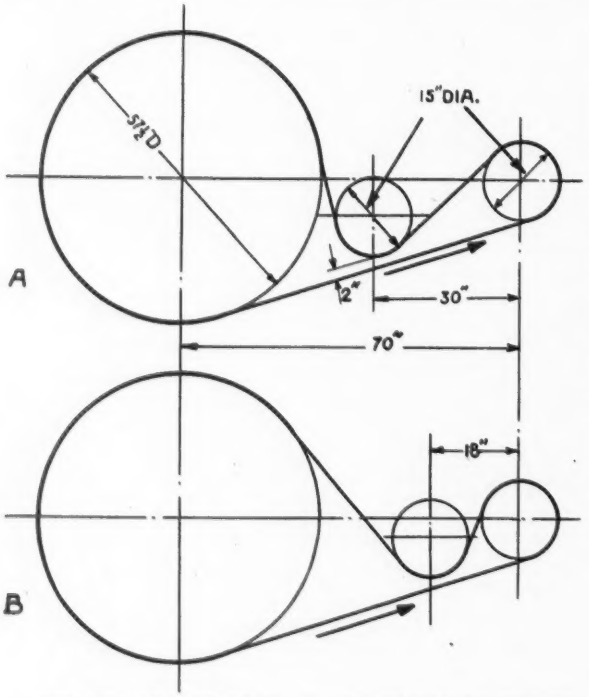
This method of testing cylinders for oil deposits was devised by my friend who admits that it may be crude and probably not the best method but it is simple and has "saved the day" for him many times. If there is a better method of determining when a cylinder is properly lubricated, he would be very glad to know about it.

Newark, N. J. W. F. SCHAPHORST.

# Questions and Answers

## Hot Belt Caused by Incorrect Installation

SLIPPAGE of the belt on a motor-driven air compressor in our plant causes the belt wheel to become so hot that it can be run only about 40 min. at a time.




A. PULLEYS AS INSTALLED. B. REDUCTION OF CENTER TO CENTER DISTANCE OF IDLER AND MOTOR PULLEYS INCREASES THE ARC OF DRIVING CONTACT

The valves are in good condition, the compressor turns over freely by hand, the rings are all right and the belt is lined up centrally on the belt pulley, idler and motor pulley. The motor runs 1150 r.p.m. and the compressor, 292 r.p.m. The motor and idler pulleys are each 15 in. dia. and the belt wheel, 57½ in. dia. After operating for 40 min., the belt pulley will run only about 200 r.p.m. although the motor pulley is still running at 1150 r.p.m. The decrease in speed is gradual.

I scraped the belt, washed it with naphtha and ran it dry without benefiting the condition. I use neatsfoot oil as a preservative but nothing seems to eliminate the slippage. The temperature in the compressor room during hot weather varies between 100 and 110 deg. but there are two other machines of the same type that give no trouble by slippage. The relative position of the pulleys are as shown in the sketch A. Can you recommend any remedy?

A. Assuming that the belt runs in the direction indicated in the sketch, your trouble may be due to the small arc of contact on the small pulley and, in order to prevent slip of belt, the belt has been tightened so that it pulls the two journals together, hence causes heating, especially of the faster running journal of the motor. Your pulley ratio, almost 4 to 1, is excessive for ordinary short belt drive.

Installation of one of the standard short belt drives would eliminate your trouble. If this cannot be done, your condition can be improved by considerably increasing the center to center distance of your pulleys.

Leather belts should be cleaned with warm water and dressing applied only when the belts become dry. Dressings should not be expected to compensate for improper installation. Melted beef tallow and castor oil preparations are excellent dressings. Resinous substances should never be used, as they cause the fibers to adhere and wear each other out by friction. A little neatsfoot oil may be used on very dry belts but frequent applications of penetrating oils make the leather soft and flabby and cause it to stretch.

You can improve your condition also by setting your idler nearer the driving pulley as shown in sketch B. This will increase the arc of contact. It is assumed that your idler pulley is held against the belt by a weighted lever or spring, as should be the case.

## Furnace Too Small and Too Low Causes Slag and Smoke

WE ARE operating a 466-hp. cross-drum, inclined water-tube boiler illustrated in the sketch to run two 600-kw. steam turbines for furnishing power for our water works pumping load and street lighting and are having trouble with heavy slag forming on the lower rows of tubes and stopping up the pass. When operating at about 150 per cent rating, we make black smoke. I have tried both light and heavy firing but am unable to prevent bad smoking.

Forced draft under five retort underfeed stoker is used. I am wondering whether the combustion space is too small or the grates set too close to the first row of tubes.

How is the combustion space figured? Is it compared with heating surface or horsepower? R. M. E.

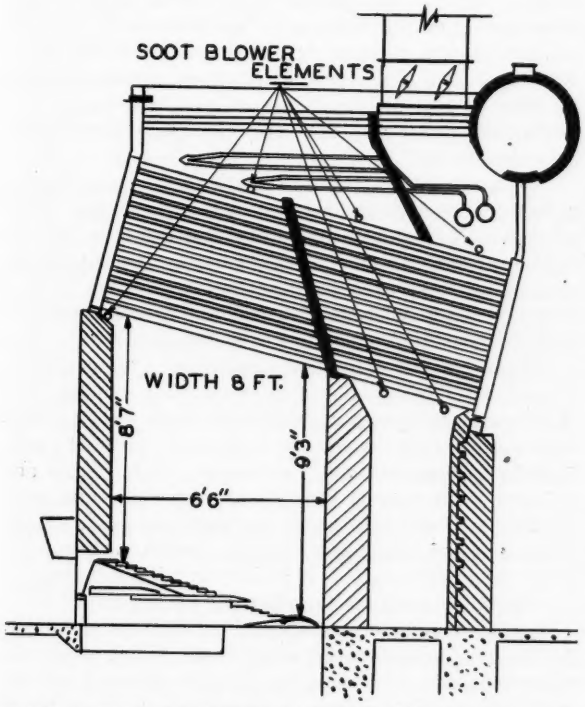
A. Examination of the data and sketch which you have submitted shows that your combustion space is too small and that your grate is located too close to the first row of tubes.

Referring to the analysis of furnace and draft practice in a table on page 1303 of December 15, 1928 issue, Power Plant Engineering, in which 23 typical, well-designed plants installed a year ago are tabulated, the

ratio of furnace volume to boiler heating surface for the underfeed stokers for the different plants is 0.628, 0.385, 0.48, 0.66, 0.36, 0.22 and 0.315, the last two being for industrial plants which usually use smaller furnaces than central stations because they are not called upon to operate under as high peak loads. Your furnace volume is 468 cu. ft., which gives a ratio of 0.105. It is clear, therefore, that your furnace should be much enlarged.

Furnace volume is usually compared to the boiler heating surface as shown in the table referred to.

Quite likely the coal contains considerable volatile matter and ash. Unless combustible gases from such a coal are given sufficient time to be consumed before they come in contact with the boiler tubes, there will be trouble due to slagging and fly ash as well as formation of much smoke. Draft being heavy under the grate




SMALL FURNACE VOLUME, LACK OF OVER FIRE DRAFT AND LOW BOILER SETTING CAUSE COMBUSTION DIFFICULTIES

and the path from the grate to the first pass being short and direct, these troubles will be aggravated. Besides increasing furnace volume and lowering the grate, it would be well to supplement present draft by introducing over-fire air through tuyeres located in the side and front furnace walls.

This will add the necessary air for the combustion of the volatile gases where they are formed and, if properly located in a sufficiently large furnace, will create turbulence of the gases and reduce, if not entirely eliminate, slag and smoke troubles at the same time raising the efficiency of the boiler and furnace.

Possibly a change to coal containing less ash and volatile matter may be desirable but, if the suggestions given are followed, there will probably be no further serious trouble.

## Head and Pipe Diameter Affect Flow

WE HAD A 16 by 14 by 28-in., 25-gal., gravity-feed oil storage tank set at an elevation of 17 ft. and fitted with internal overflow. This was replaced by a tank 28 by 28 by 58 in. having a capacity of 200 gal. and elevation of 15 ft. There are three ½-in. valves, one ¾-in. valve and two ⅜-in. valves opening into the turbine oiling system. The outlet from the large tank is 1½ in. The smaller tank had been fitted with a 1½-in. outlet. Could it not have handled the demand?

Suppose that the smaller tank had been fitted with the 1½-in. outlet, is it not true that the oil pressure would have been greater at the valves leading to the turbine oiling system?

It is claimed that with the larger tank more oil will flow to the turbines. Is it not true that, if a tank of unlimited dimensions be installed, elevation remaining the same, the same size valves being used at the turbine and any size outlet from tank above 1½ in. dia. that the amount of oil delivered to the turbines will remain the same? R. C. S.

A. Assuming the smaller tank to have had an outlet smaller than 1½ in., it is true that, if it had been fitted later with a 1½-in. outlet, the running oil pressure at the turbine oil valve would have been greater than it was before, because of the reduced friction in the larger sized pipe. There would be no change in the static pressure.

If, in each case, the elevation is taken to be the difference in height between the level of oil in the tank and that of the center line of the oil valve, this pressure would also have been greater proportionally than that obtained by use of the new tank, because of the greater head of the smaller tank.

If the level of oil in the tanks was maintained constant at the elevations stated, the smaller tank with 1½-in. outlet would have supplied oil at a faster rate than the larger tank. The latter would have an advantage over the former, however, in keeping the oil cooler. If the level difference changes, the rate of flow will be in proportion to the actual head at the time.

It is not true that for outlets over 1½ in. dia. the rate of supplying oil to the turbine for constant elevation and valve sizes, would remain constant. The rate of flow depends upon the size of pipe because of the greater friction in the smaller sizes.

## Direct and Indirect Action Engine Valves

ARE CORLISS valves of the direct or indirect type? M. L. S.

A Corliss exhaust valves are direct acting, while the steam valves are indirect, since the latter have a releasing mechanism and the quick action of cutting off the steam is accomplished by the partial vacuum in the dash pot, not by mechanical means.

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PROPAGATION of flame through a coal and air mixture depends upon the turbulence, quality, fineness and ash content of the coal and the ratio of air to coal. In a furnace, any coal of a particular fineness should be supplied with sufficient air at the burner to give the highest flame propagation. If the air supply is above or below the proper ratio, propagation is retarded.

# Editorial Comment

## Nickel Steam

Spite of all the talking and writing that has been done, waste of exhaust steam goes on steadily. It is pouring out of almost every factory and individual plant building that you pass.

During the summer, there may be excuse for this as steam cannot be bottled up and saved until winter. But in winter every heat unit possible in every pound of coal should be utilized. Some heat will escape up the stack, spite of all precautions but that is all that should get away without doing something useful.

At best, your engine or turbine will transform hardly more than 20 per cent of the heat energy of steam into mechanical energy. That means one horsepower-hour to a pound of coal, of 14,000 B.t.u. heat value. The chances are great that your plant is not doing as well as that.

Then 80 per cent or more of the heat energy is left in the exhaust steam. What becomes of that? It can be used! Heating feedwater, heating buildings, heating house water, cooking, preheating furnace air, process heating,—what of these are needed in your plant? If your plant cannot use all the heat from exhaust, how about your next door neighbor? He may need heat and be glad to buy it. Even somebody across or down the street may need heat. The pipe line would be a one-time investment; the waste of steam is continuous. His expense for operating a heating boiler is continuous. Have you looked around to see whether the escaping steam can be put to work?

On the other hand, if you are making steam solely for heating or process work, perhaps your neighbor is wasting exhaust that you could buy at less than it costs you to make it. Have you looked into this? Why make steam if you can buy it cheaper?

If you dropped a nickel, would you pick it up? If your pocket let a nickel fall out every 15 min., would you have it fixed? Counting cost, transportation, handling and firing, it's a safe guess that every shovelful of coal that goes into the furnace represents a nickel. It will give say 100 lb. of exhaust steam. Steam for heating from central plants sells at 50 to 60 cents per 1000 lb. A square foot of radiator surface will use 500 lb. a season. That's five nickels used for each square foot of radiation. For a room 15 by 15 ft. and 10 ft. high, 30 sq. ft. of radiation is needed. That's 150 nickels, quite a pocketful, to heat one small room. How many to heat the buildings in your plant?

It's time, by the way, right now to get ready for the winter months. How many nickels can be salvaged from that exhaust pipe? And have you bought your winter fuel? Prices are usually lower before cold weather sets in. Some more nickels might be saved there. Twenty nickels make a dollar. And even the new, apartment-size dollars are worth saving.

## Dust Explosions

Dangers of dust explosions in industrial plants have been and are being studied in detail by government and private agencies in an endeavor to avoid further loss of life and property in approximately 28,000 industrial plants employing almost a million and a half people.

Many, but by no means all, dust explosions occur during the normal operation of the plant. Many fatal accidents occur during the period of fire fighting, accidents which are preventable by proper methods of construction or of fire fighting. Explosions have followed a heavy stream of water striking powdered material and forcing it into the flames, by chemical action of water on piles of dust and by falling of buildings or portions of building which dislodged dust clouds and forced them into the fire.

It is the latter which is particularly dangerous in power plants and probably accounts for several minor explosions which often follow the first one or a fire. In both coal burning and wood waste burning plants, the amount of dust which will accumulate on the tops of boilers, piping and beams is considerable and constitutes a fire menace which should not be tolerated.

Many modern plants are eliminating this menace by entirely enclosing the fuel conveying system and bunkers as well as by designing buildings either so that dust cannot lodge or so that they can be cleaned easily, usually by means of vacuum cleaners. A few years ago, a boiler room painted throughout with aluminum paint would have been considered the height of folly. Nowadays it is considered good practice which, although not yet universally adopted, is rapidly gaining headway.

There is no excuse for allowing the accumulation of either wood waste or coal dust along the tops of bunker, boilers and beams in the boiler room. Such accumulations represent a fuel loss but more important than that they represent a fire and explosion hazard which makes death traps out of what may otherwise be safe and well designed plants.

## Profits From Nonproductive Improvements

Some power plants may need more efficient equipment, others, additional instruments or newly developed equipment which will permit changes in the heat cycle in order to bring their efficiencies up to modern practice. The value of such improvements can readily be determined. It is more speculative, however, to estimate what the profits might be on investments that improve working conditions.

Adequate lighting facilities, healthful atmospheric conditions, clean floors, walls, ceilings and corners, polished brass rails and fittings, orderly shelves and cupboards, convenient and sanitary lavatories and lockers, strictly enforced safety rules, carefully chosen first aid equipment, all these are becoming more and more common in power plants. So also are higher efficiencies and

lower fuel requirements per kilowatt-hour of output.

Have the latter results come because of better working conditions? Is there a more intelligent class of men in charge of power plant operation than in the days when coal consumption was higher? Have not the improved working conditions attracted men who have a keener knowledge of the problems at hand? Certainly all credit for improved plant economy can not be given to the designer of equipment. The operating force in the power plant must take responsibility for results secured and, when considering investments for power plant improvements, some consideration should be given to the psychological effect of better working conditions.

## Off Duty

Do you have ice in your boiler? The answer is yes!

These inquisitive research men are always upsetting our best certainties. There was Einstein proving, or so it seemed, that if you look straight ahead in space far enough you can see your own back. And an atom is no longer an indivisible piece of elementary matter but it's a whole universe of electrons. Now, it appears that water isn't just something to wash in. It's an arena for a gang war between individuals, twins and triplets. Maybe even that isn't so but it seems to explain some of the erratic behavior of ice.

It seems that pure water, consisting entirely of orderly individuals, $H_2O$ molecules, is found only as dry steam or vapor. When it, as we naively say, condenses, what really happens is twins or double molecules $(H_2O)_2$ and triplets $(H_2O)_3$. But the queer thing is that the triplets are ice. So, according to the strength of the twins or triplets gangs, we have liquid water or solid water but there are always some ice triplets until the temperature of the water is raised to 368 deg. Cent. (694 deg. F.) when all the triplets have shifted over into twins. This hasn't reduced the number of $H_2O$ molecules, only the arrangement, so it's no use for surprised fathers to try to get rid of triplets by making it hot for them. They are all there only the gang alinement has changed.

When you call for a glass of ice water, the up-to-date waiter may bring you ordinary faucet water at 68 deg. F. with the statement that, "Dr. Sutherland says that's 32 per cent liquid ice and what do you expect? " Even your bath water at 158 deg. is 25.5 per cent ice. Now shiver. Why should these January 1st outdoor bathers be so cocky? Everybody bathes in ice water. Why even at 212 deg. or boiling point water is still 21.7 per cent ice. And in your boiler at 200 lb. pressure, the water is 16 per cent ice. But all the triplet and twin gangs break up into individuals when they turn into dry steam.

So long as the temperature stays at or above freezing, 32 deg. F., the twins are in the majority and hustle the triplets around so that they can't organize. But a change of a thousandth of a degree may get the twins dopey and then watch those triplets get together. They collect into a mob as flat disks and quickly form ranks as crystals, the colder the faster.

That's why frazil ice forms. Any time the temperature gets below freezing, the triplet molecules begin to organize. They gang up to each other in midstream all through the water and may become attached to the shore or to a rock or log on the bottom. If the latter, it's anchor ice. And how they can make trouble in a forebay or turbine casing!

By the way, the individual $H_2O$ molecule is called a hydrol, the twin a dihydrol and the triplet a trihydrol, so it's the trihydrol which is the villain, but he can make trouble only when he gets too numerous for the dihydrol gang to handle.

Like most gangsters, Mr. trihydrol is dispersed by light and by making it hot for him. The radiant energy of sunlight as well as the sun heat are just too bad so far as he is concerned and frazil ice just fades away when the morning sun hits it.

But here's another queer one. Just like gangsters, if you take away the leaders, it takes quite a while for new ones to grow enough to head the gang. We have known that water, if kept quiet, can be cooled below freezing without turning to ice but, if there is any disturbance, ice crystals form. So long as the trihydrol gangsters can't move to get together, the dihydrol twins can hold them.

To see what would happen, a tank of water was cooled to 15 deg. below freezing and let stand a half hour. Then the ice was taken out, a pailful. It took a whole hour for another pailful to form and, after that was taken out, two hours for the third pailful. With the third pailful out, no ice was formed for four hours, yet the temperature was the same. Evidently the trihydrol gang was about cleaned out.

Yet, with the remaining water warmed to room temperature and again cooled, ice formation started up briskly. The hot time evidently converted some of the dihydrol twins into trihydrol gang leaders. So by heating the water above freezing, ice was produced. Another fixed and definite idea gone to the bad.

Now comes Professor Howard T. Barnes of McGill University up in Toronto where ice *is* ice to put this new understanding of ice formation to use. Any condition that favors radiation of heat from water which is near freezing temperature favors the organizing of the trihydrol gangs. Any condition that retards radiation, hinders that gang formation. Light, heat, high humidity, a warm rain, small exposed surface are hindrances. Also it's easier and cheaper to prevent the accumulation of frazil ice than to get rid of it after it forms into solid masses.

Professor Barnes' argument is that dynamiting an ice jam results mostly in blowing the air away, with little result on the ice except to jam it together harder. But, if you go after it with Thermit, the ice is split up into oxygen and hydrogen; the oxygen unites with the iron of the Thermit mixture and the hydrogen burns with air in a hot sheet on the surface of the ice. "The ice blasts itself," becoming cracked and rotted so that it easily breaks up. Any substance, such as cinders or gravel, which will draw the sun's heat will aid in rotting ice. We all know the effect of common salt or of sodium chloride in clearing sidewalks of ice. These are helps to the hydraulic plant engineer in handling his winter problems but the best way is to stop the frazil ice gangsters from organizing and a strong flood light may do the trick.

Fortunately, although the steam plant engineer has trihydrol ice triplets in his boiler, they don't get to gang up there so he hasn't to resort to Thermit burning or it might go hard with the shell of the boiler.

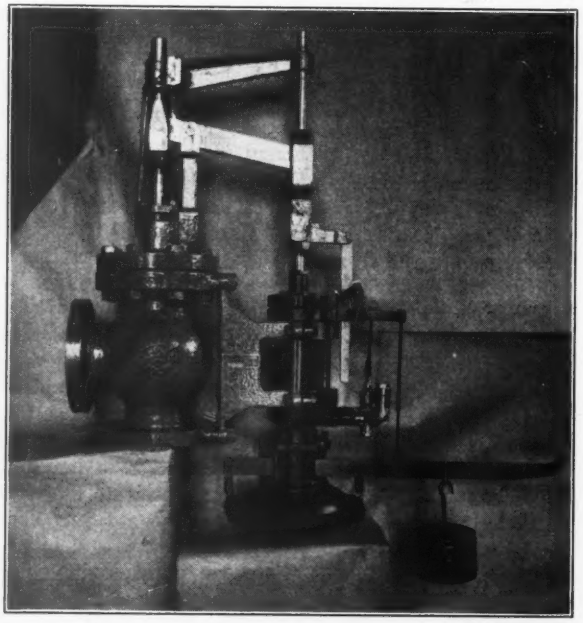
# Power Plant Engineering Developments and News

## R-K Heavy-Duty Pressure Regulators

DESIGNED for high initial pressures up to 1350 lb. and for total temperatures of 800 deg. F., the R-K heavy-duty, self-contained, step-action reducing pressure regulator has recently been announced by Rugglesâ€“Klingemann Mfg. Co., Salem, Mass. This regulator has been developed to provide reliable control of heavy construction, adapted to central generating station requirements. The present sizes are from 4 in. to 14 in. in the straightway type and 4 in. to 10 in. in the angle type. Sizes 2 in. to 4 in. inclusive are made single seated with Venturi orifice construction.

Distinguishing feature of this regulator, it is stated, is that it is mounted direct to the valve which it controls, as shown. The regulator itself is similar to the company's standard step-action machine, having power motor operated by water pressure. Variations in pressure on the diaphragm operate a pilot valve to a pressure position which operates the motor; the operation of the motor returns the pilot valve to its neutral position at each step position on the compensating step wedge, the arrangement being designed so that, under normal conditions, there will be no tendency to overcorrection or hunting action.

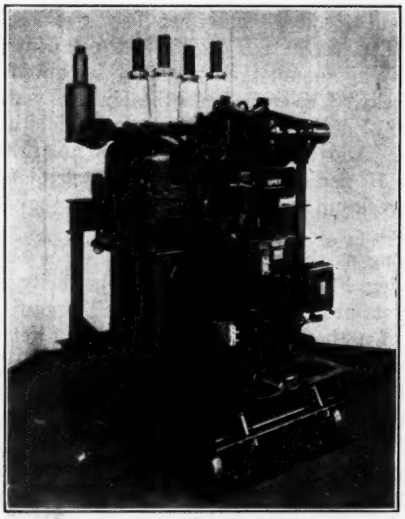
This regulator is intended for the following applications: for maintaining uniform steam pressure in a low-pressure header for use in connection with old turbines and auxiliaries in a two-pressure system; for supplying make-up steam to deaerators and evaporators; to operate as a blowover valve for unloading steam pressure from a high to a low-pressure header where boilers are operated at different pressures; for operating on bypass to maintain uniform exhaust pressure in connection with noncondensing high-pressure turbines.



HEAVY-DUTY, SELF-CONTAINED PRESSURE REGULATOR IS MOUNTED DIRECTLY ON THE VALVE IT CONTROLS

## Type F-120-15D Oil Circuit Breaker

INTENDED for high current-carrying capacity combined with high interrupting ability the type F-120-15D 4000-amp. truck-type, oil circuit breaker for 15,000-v. service, a heavy duty addition to its F-120 line of power breakers, has been announced by the Condit Electrical Mfg. Corp., Boston, Mass. Contact system, studs, bushings and mechanism are firmly supported by a massive, dome-shaped, cast-steel top which is in turn supported by a channel and angle iron structure on wheels. The tank is of boiler plate steel, cylindrical in shape with rounded bottom supported from the frame by a number of short heavy bolts. A



TYPE F-120-15D OIL CIRCUIT BREAKER IS RUGGEDLY BUILT

deep reinforcing flange on the pole top extends down over the tank for several inches.

To afford the necessary current capacity without undue heating, four studs per pole unit are used, each with a capacity of 2000 amp. Inside the breaker, these studs are clamped in a pair of heavy contact blocks, two studs to each block. From each block extend three inverted laminated brushes, all of which make firm contact with a single bridging member of heavy copper.

Arcing contacts are designed on the principle of energy absorption. Eight heavy cylindrical blocks of copper are provided to afford such thermal absorption capacity as to materially reduce arcing on interrupting. Four series breaks are used to further reduce the duration of arcing. The design of the arcing contact circuit makes use of the electro-magnetic forces developed on high current rushes to insure that arcing contacts remain closed with strong pressure until the brushes have safely parted. The type F-120-15D, it is stated, has an estimated interrupting capacity of 1,000,000 kv-a. at 15,000 v.

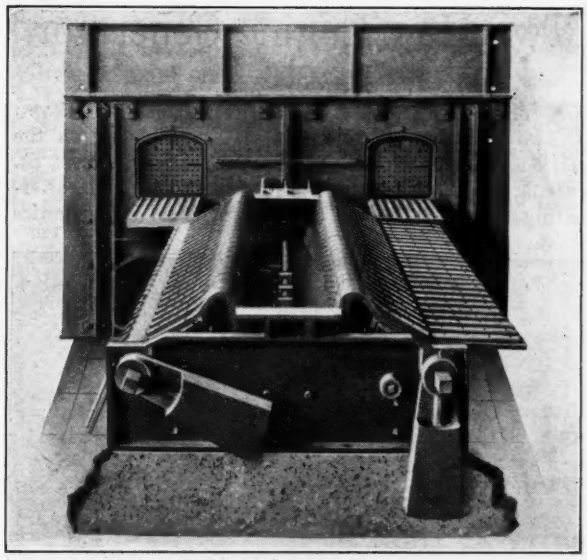


FIG. 1. REAR VIEW OF NEW TYPE S R STOKER SHOWS TUYERES, GRATE BARS AND COUNTER-BALANCED DUMP PLATES

# Type SR Underfeed Stoker

ESPECIALLY DESIGNED for burning coking and non-coking bituminous coal, the McClave type SR underfeed stoker has recently been placed on the market. This is a multi-zone stoker of the single-retort, side cleaning type, as shown in the illustrations, with a fully enclosed driving unit, designed for firing boilers of from 50 hp. to 300 hp. capacity. The smaller units are designed for single drive of stoker and fan from one motor, the fan being located at the front of the stoker; larger units are designed for individual stoker and fan drive. Driving units are completely enclosed to protect the mechanism from dust or breakage.

Figure 2 shows the coal feeding mechanism and retort construction. The mechanically driven ram is provided with an adjusting pin for regulating the feed, while the stroke of the retort pusher rod also has an adjustment as shown. To eliminate a shearing pin, a special friction safety clutch is used. Coal distributing shoes are designed to be adjustable.

To allow for contraction and expansion, a special sectional cast-iron stoker front is provided, the fire doors being equipped with a special latch to allow quick and easy opening and with separate fire-door frames. To support the front wall of the setting, sectional retort arch plates are used, designed to be replaced without disturbing the brickwork.

Tuyere blocks are of sectional design with staggered mesh design to permit equal air spaces, while the sectional, rabbeted grate bars are of heavy construction, designed for proper air spaces, the air being separately zoned under these bars. They are located between the tuyeres and dump plates, Fig. 1. Renewable ash dump plates have special reënforcing ribs and air space to burn out the coal completely below dumping. Counterbalance weights on these dump plates are installed to facilitate dumping. Special dampers are provided to zone the air to the tuyeres, grate bars and ash dump plates, to control air to every part of the fire. This new stoker is a product of McClave-Brooks Co., Scranton, Pa.

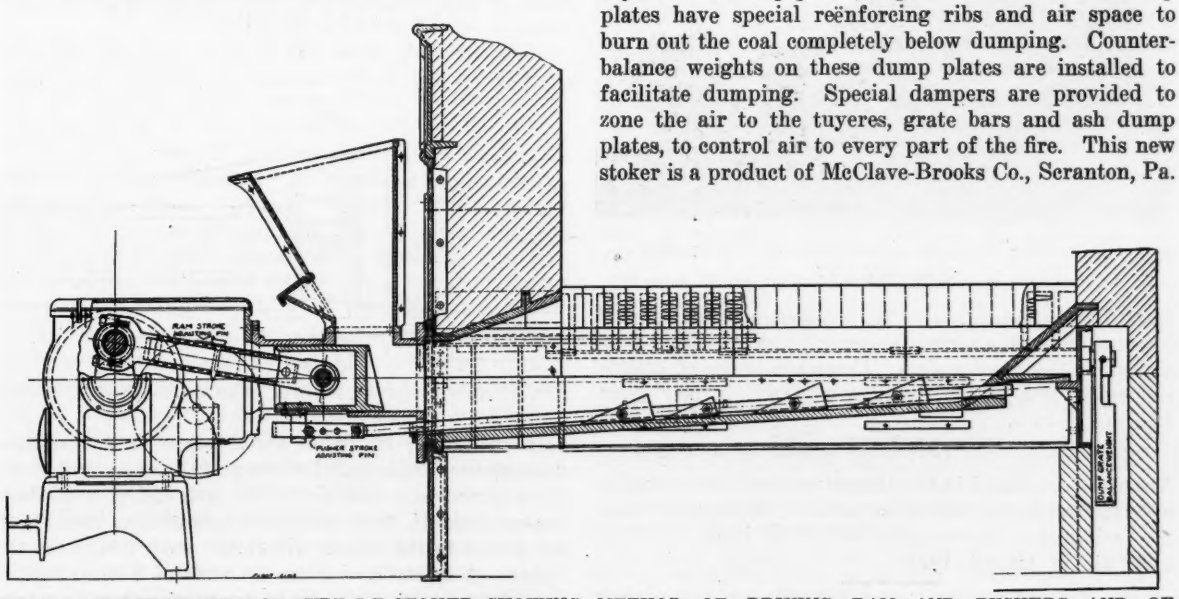


FIG. 2. SIDE ELEVATION OF TYPE S R STOKER, SHOWING METHOD OF DRIVING RAM AND PUSHERS AND OF ADJUSTING THEIR STROKES

# Two New Engine-Generator Sets

IN THE ACCOMPANYING illustrations are shown two new engine generator sets just placed on the market by Engberg's Electric & Mechanical Works, St. Joseph, Mich. Figure 1 shows a Texrope drive, alternating-current set which can be furnished in capacities

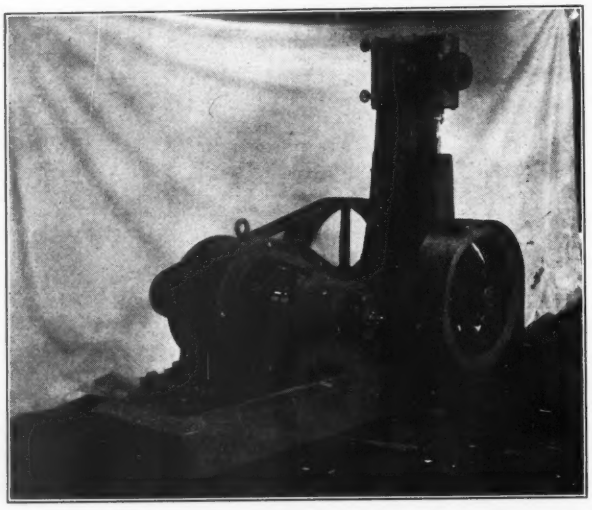


FIG. 1. ALTERNATING-CURRENT SET WITH TEXROPE DRIVE

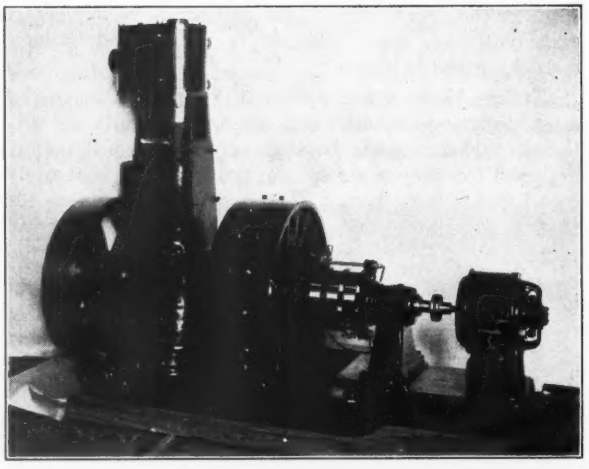


FIG. 2. NEW DIRECT-CONNECTED ALTERNATING-CURRENT SET

from 3 to 31.25 kv-a. In Fig. 2 is shown a new type of direct-connected alternating-current set which is furnished in the smaller sizes. Complete range of direct-connected sets, the manufacturer states, is now from 12.5 to 125 kv-a.

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NEW ORDERS for 1861 steel boilers were placed in August, as reported to the Department of Commerce by 80 manufacturers comprising most of the leading firms in the industry, as compared with 2054 boilers in July and 2018 in August, 1928.

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THERE IS a definite tendency toward the use of 2200-v. motor driven power plant auxiliaries.

# Motor Drive for Type E and Type K Stokers

ELECTRIC MOTOR DRIVE has recently been developed which is applicable to either of the Type E and Type K underfeed stokers, manufactured by Combustion Engineering Corp., New York. This drive consists of a double-worm gear reduction unit and a Reeves variable-speed transmission unit. The gear case assembly is compact; all parts are fully encased, yet readily accessible. The motor is located on the flat, top surface of the gear case which provides a convenient and solid support. Furthermore, in this position the motor is well removed from the floor dirt of the boiler room and is out of the way when the floors are washed. Access to the fire doors is not hindered in any way.

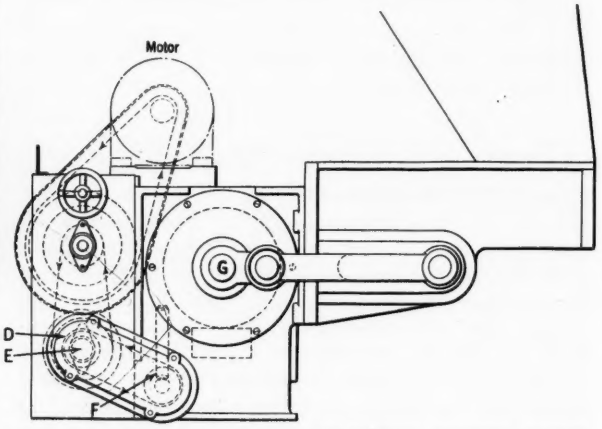


FIG. 1. SIDE VIEW OF NEW ELECTRIC STOKER DRIVE

The Reeves mechanism is driven by a silent chain from the motor as shown in Fig. 1. On the opposite side is the hand-wheel, conveniently located, for adjusting the speed changes. The ratio of speed change is from 1 to 8, which is considered ample for the usual range of combustion rates. For indicating the relative speed, a pointer device is mounted.

A silent chain drive, Fig. 1, at D, connects the lower shaft, E, of the Reeves mechanism with the first worm

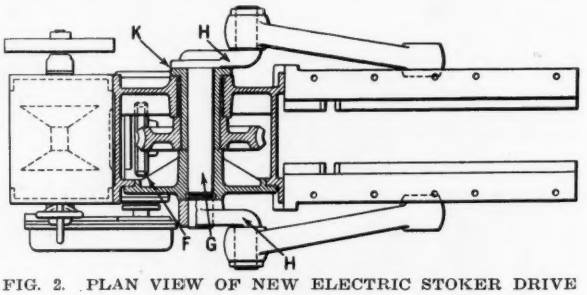


FIG. 2. PLAN VIEW OF NEW ELECTRIC STOKER DRIVE

gear reduction, F, from which power is transmitted through the double set of worm gears to the crank shaft, G. Figure 2 is a plan view. On each end of crankshaft G are cranks H, from which twin connecting rods transmit power to the under side of the pusher block of the stoker. A safety device, in the form of a shear key, is provided to protect the stoker mechanism from breakage in case the stoker feed is obstructed in any way. This

shear key, located at K, is particularly convenient for replacement, since it is on the outside of the casing.

When a steam pressure regulator is used to secure automatic control of the stoker speed, a lever is substituted for the hand-wheel control of the Reeves drive.

The power required to drive either the Type E or Type K stoker, it is stated, is low. Inasmuch as high-speed motors are often preferable on account of their lower cost, the electric drive has been designed so that it is applicable to the use of either high-speed or low-speed motors.

# Death of Geo. A. Goodenough

GEORGE A. GOODENOUGH, professor of thermodynamics at the University of Illinois, died of heart disease at his home in Urbana, Ill., on September 30. He was 61 yr. old. He had been in poor health since last summer, when he suffered a stroke of paralysis.

Professor Goodenough's work in steam table research is too well known to all power plant engineers to need further comment. He was author of many technical articles and books, including Principles of Thermodynamics, Essentials of Calculus, First Course in Calculus, chapters on thermodynamics in various engineering handbooks.

Born on May 3, 1868, at Davidson, Mich., Professor Goodenough attended Flint High School, received his degree of bachelor of science at Michigan Agricultural College and his master's degree in mechanical engineering at the University of Illinois in 1900, a year after joining the faculty. In 1909 and 1910 he was acting head of the department of mechanical engineering at the university. To followers of sports in the Middle West, Professor Goodenough was widely known as chairman of the western conference faculty committee on athletics and on eligibility.

# N. E. L. A. Engineers To Meet at Madison Oct. 23

ENGINEERING SECTION, Great Lakes Division, National Electric Light Association, is to hold its 1929 fall meeting in the Loraine Hotel, Madison, Wis., from October 23 to 26. Wednesday, October 23, will be devoted to meetings of Accident Prevention, Overhead Systems, Power Systems Engineering and Prime Movers Committees. On the morning of Thursday, October 24, a general open meeting on Power System Stability will be held, sponsored by Electrical Apparatus Committee, Hydraulic Power Committee and Prime Movers Committee.

The following papers are scheduled for presentation: The General Stability Situation, Alex D. Bailey, Chairman Engineering National Section; Power System Stability as affected by Hydraulic Plant Design by Forrest Nagler, Hydraulic Engineer, Allis-Chalmers Mfg. Co.; Power System Stability as affected by Steam Plant and Substation Design by Robert Treat, Central Station Engr. Dept., General Electric Co. In the afternoon, two other papers on the subject will be presented, as follows: Power System Stability as affected by Transmission System Design by C. L. Fortescue, Consulting Transmission Engr., Westinghouse Electric & Mfg. Co.; Power System Stability as Affected by General System Characteristics by J. H. Foote, Electrical Engineer, Stevens & Wood, Inc.

Late in the afternoon, inspection trips will be made to University of Wisconsin buildings and laboratories, steam plant of the Madison Gas & Electric Co. and the underground system and a.c. networks of that company. In the evening, the banquet will be addressed by Governor Kohler of Wisconsin.

On Friday, meetings of other committees will be held. On Saturday morning, there will be an inspection trip to the Prairie du Sac hydroelectric plant and in the afternoon members will witness the football game between Wisconsin and Iowa. Further details regarding the meeting can be obtained from Tom C. Polk, Secretary, Great Lakes Division, N. E. L. A., Room 910, 140 So. Dearborn St., Chicago.

# News Notes

FOURTH NATIONAL MEETING of Wood Industries Division of the American Society of Mechanical Engineers is to be held at Rockford, Ill., on October 16, 17 and 18. Among the subjects to be discussed are: Coördination of Production and Distribution of Wood Products, Making Animal Glue Water Resistant, Design of Precision Machinery for Piano Action Parts, Theory of Boring and Mortising of Wood, High-Speed Cutter Heads, Mass Production of Radio Cabinets, Principles of Wood Bending. Inspection trips to nearby manufacturing plants and various entertainment features are also announced. Headquarters of the meeting are at the Hotel Faust, Rockford, Ill. Further information can be obtained from the Committee in Charge of Program, of which J. H. Mansfield is chairman.

CONTROLLING INTEREST in the Dixie Power Co., which serves 18 communities in Washington and Iron Counties, Utah, with electric power, has been sold to W. B. Foshay Co., according to an announcement made today by Lafayette Hanchett of Salt Lake, who, until the sale, was one of the principal shareholders in the company. The purchase includes four hydroelectric generating plants, one Diesel engine generating plant, and approximately 300 mi. of transmission lines. Power lines of the Foshay Co. in Arizona are less than 100 mi. from the lines of the Dixie Power Co. It is reported that these will probably be joined in the near future.

ADDRESSING a civic club in Des Moines, Iowa, recently, C. A. Leland, Jr., vice-president and general manager of the Des Moines Electric Light Co., declared that his corporation will be compelled within the next two or three years to erect a $3,000,000 addition to the $7,000,000 generating plant completed only a few years ago. The old plant on Center St. at the Des Moines River, which has been kept in condition as a standby unit, is already being operated to handle some peak loads and as soon as the seasonal peak is felt will be operated continuously, necessitating plans for early provision of a reserve station.

TERRY STEAM TURBINE Co., Hartford, Conn., announces the appointment of Farrell & Jones as Boston representatives. Farrell & Jones will be located at 10 High St., Boston, Mass., and their territory will include the states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and the eastern part of Connecticut.

MARION MACHINE, FOUNDRY & SUPPLY Co., Marion, Ind., has opened an office in Chicago in Room 1022, Insurance Center Building, 330 South Wells St. J. Mack Wilson, formerly sales manager Home Division, is in charge of the Chicago office.

W. J. BERTKE has succeeded C. I. Crippen, New York City, as president of the Iowa Public Service, Sioux City Gas and Electric and Sioux City Service Companies as well as the subsidiary companies of the Iowa group, serving 200 communities. Mr. Bertke was vice-president and general manager of the Sioux City Gas and Electric Co. the last few months and will continue as general manager of that company in addition to his duties as supervisor of all the other utilities of the group. Mr. Crippen becomes vice-president of the companies involved.

RALPH H. GARRISON, Waterloo, Iowa, the past year manager of the Cedar Valley division of the Iowa Public Service Co., with which he has been associated 5 yr., joined the executive staff of the Utilities Power & Light Corp., Chicago, Oct. 1, it was recently announced.

De Laval Steam Turbine Co. announced that it has taken a license to manufacture steam turbines and gears to utilize exhaust from reciprocating engines, particularly on shipboard, under American Bauer-Wach patents. Dr. Gustav Bauer, whose name the patents bear, is the engineer responsible for the machinery of the record-breaking North German Lloyd steamer Bremen.

For the convenience of midwestern industry, a factory branch of The Brown Instrument Co. has been established at 217 E. Illinois St., Chicago, Ill.

Oapalite, a protective paint for waterproofing brick and concrete walls, for preventing corrosion of pipe and steel structures and for insulating underground pipe against stray electric currents is being placed on the market by Merritt Products Co. of 1666 Wright St., Chicago, Ill., which offers to send samples on request for service tests.

Southwestern Power Co., a subsidiary of the Mexican Light & Power Co., Mexico City, Mexico, is completing a large dam near Tepuxtepec, State of Michoacan, to be used in connection with a hydroelectric power development now under way. The new dam will impound water from the Lerma River and will be used in connection with power station for developing a maximum of about 45,000 hp. The initial plant will be equipped with two water turbines and two generators of 15,000 hp., and another unit of the same size is scheduled for installation at a later date. The project will include an extensive transmission system, as well as an irrigation development, and is estimated to cost 20,000,000 pesos (about $10,000,000 United States currency).

Pennsylvania Pump & Compressor Co., Easton, Pa., announces the appointment of Joseph W. Eshelman as its representative in the Birmingham, Alabama, district with headquarters in American Traders Bank Bldg.

For turning on and off blowers, ventilators and electrical apparatus that can be operated on a predetermined time basis, the Sauter Self-Winding Time Switch has recently been placed on the market. The main switch of this device is designed to be motor-operated, air-break, rotary, self-wiping and quick acting. Contacts are designed for constant load at rated capacity plus 25 per cent over load. It is equipped with a universal series-wound motor, with jumper arrangement on the field coils for multiple or series connection, making the motor operative on 115 and 230 v. d.c. or a.c. of any frequency, with a permissible voltage fluctuation of plus or minus 20 per cent. The self-winding clock is designed with a positive and simple mechanical release to prevent overwinding and can be furnished with a Sunday cutout. This switch is marketed by R. W. Cramer & Co., Inc., 136 Liberty St., New York City.

H. D. Conkey & Co., Mendota, Ill., is building an addition to its plant at Mendota, Ill., to double its capacity. The company also announces that it has appointed Cleveland Tool & Supply Co. of Cleveland, Ohio, as its representative in the Cleveland District.

McClave-Brooks Co., Scranton, Pa., announces that it has just appointed Frederick D. Rodgers, 141 Milk St., Boston, Mass., as its commission representative.

At the Charles R. Huntley steam plant of the Buffalo General Electric Co., Buffalo, N. Y., a new 100,000-hp. turbine-generator unit is to be installed in the near future in addition to the 107,000-hp. extension begun last July, on which work is now under way. When these two new prime movers are completed, the total capacity of the Huntley Station, it is announced, will be 540,000 hp.

According to a recent announcement, Howard Butt, formerly sales manager of the Air Preheater Corp., is now connected with the Hahn Engineering Co., a division of Lancaster Iron Works, Inc., Lancaster, Pa. Mr. Butt is located at the New York office, 101 Park Ave.

Eastern Massachusetts Electric Co., Washington St., Salem, Mass., has plans under way for a steam power plant in the vicinity of the local pier of the Philadelphia & Reading Railway. The new station, it is reported, will cost over $10,000,000 and the project will include an extensive transmission system. Engineering and construction work will be carried out under the direction of Charles H. Tenney & Co., 200 Devonshire St., Boston, Mass., which operates the electric company.

Sullivan Machinery Co., Chicago, Ill., announces that on September 1 its branch office and warehouse at Huntington, W. Va., were moved from the old address at 736 Third Ave. to 702-704 Eighth Ave. J. S. Walker, Jr., is manager of the Huntington office.

Rumsey W. Scott for the past five years president of the American Cable Co., has resigned to join the Commercial Investment Trust, Inc., as a vice-president. Previous to his connection with the American Cable Co., he was vice-president for four years of the Chemical National Bank and prior to that was with the Otis Elevator Co. for 17 yr. He is a member of the A.S.M.E. and other technical organizations.

Girtanner Engineering Corp., New York City, announces that Anthony G. Fleck has joined its organization as mechanical engineer in charge of all construction with headquarters at 122 Greenwich St., New York City.

Sullivan Machinery Co., Chicago, announces the death on August 25 of Ray P. McGrath, for 15 yr. manager of its San Francisco office. He had been associated with the company since 1906. The company advises that Perry W. Oliver, a member of the Sullivan organization since 1914, has been appointed manager of the San Francisco office to succeed the late Mr. McGrath.

Bailey Meter Co., Cleveland, Ohio, announces that its Boston office, in charge of P. T. Reuter, has been transferred to new and larger quarters at 523 Public Service Bldg., 89 Broad St., Boston, Mass.

Michigan Valve & Foundry Co., Detroit, Mich., has recently appointed the Herbert Kennedy Co., 22 East 42nd St., New York City, as its representative in New York and New England. The Herbert Kennedy Co. is also selling agent in the United States for the Pont-A-Mousson Cast Iron Foundries at Nancy, France, and Inter-Continental Pipe & Mining Co., now building a large pipe foundry at Chelsea, Mass.

Soviet Russian Government, Moscow, according to a recent announcement, has arranged a program of power plant construction during the fiscal year, 1929-30, beginning in October, to cost approximately $207,500,000. The program provides for the construction of 10 central stations varying in capacity from 22,000 to 150,000 kw., with transmission lines. Active work is now in progress, it is stated, on the Dnieper River hydroelectric project, under the direction of Hugh L. Cooper, 101 Park Ave., New York City, consulting engineer. This plant, as previously noted. is to have a capacity of 800,000 hp. in ten units. Contract was recently placed for four of these units with the Newport News Shipbuilding & Dry Dock Co., Newport News, Va., and the International General Electric Co., New York

Wagner Electric Corp., St. Louis, Mo., announces the opening of a new branch sales office at 734 Allen Bldg., Dallas, Texas, in charge of Alfred B. Emrick, to cover the entire state of Texas and parts of Louisiana and Arkansas.

Foster Wheeler Corp., New York City, announces the appointment of P. J. Cleary as manager of its Atlanta office. Mr. Cleary was with the Westinghouse Electric & Mfg. Co. as sales engineer, handling mechanical stokers and other steam equipment for a period of 15 yr. Subsequently he joined Combustion Engineering Co. as its district manager in the southeast. He is a member of the American Society of Mechanical Engineers.

The Central Illinois Public Service Co., serving about a third of Illinois in the central district with electric power, will begin clearing site at Sixth and Adams Sts., Springfield, Ill., November 1, for a new million-dollar 15-story office building, which is scheduled to be completed January 1, 1931.

Directors of the Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., announce that George D. Kingsland will be in charge of the unit heater control division, effective October 1. Mr. Kingsland has been associated with the Minneapolis-Honeywell Co. for many years, first as a distributor of the company's products in St. Louis and later as manager of that branch office. In 1925, he was made manager of the New England branch office, in which capacity he has served until his recent appointment.

Belmont Packing & Rubber Co., Philadelphia, Pa., announces that additions have been made to its plant bringing the manufacturing space up to approximately 110,000 sq. ft.

Five boilers of the new plant which is being installed at the Issy-les-Moulineaux Power Station in the suburbs of Paris by the Compagnie Parisienne de Distribution d'Electricite are being arranged for pulverized fuel firing to generate steam at a pressure of 625 lb. per sq. in. The steam will be utilized at a total temperature of 842 deg. F. in two 11,000-kw. back-pressure turbine generators and subsequently in an existing 40,000-kw. set.

Although the largest Ljungstrom steam turbine to run at a speed of 3000 r.p.m. so far constructed is that recently built for the power station at Leghorn, Italy, of the Societa Ligure Toscana di Elettricita, the Svenska Turbinfabriks Aktiebolag Ljungstrom of Stockholm, Sweden, is now constructing a 27,000-kw. turbine-generator set to run at that speed and is engaged on the designs of sets of 30,000 and 40,000 kw. capacity.

What is claimed to be the largest Ruths steam accumulator installation so far built has lately been completed at the Central Electric Power Station at Charlottenburg, Germany. The installation comprises no fewer than sixteen vertical accumulators 68 ft.

high and 16½ ft. in diameter. Steam from the boilers is first used to operate turbine-generator sets at a pressure of 35 atmospheres (500 lb. per sq. in.) whence it passes to the Ruths accumulators at a pressure of 13 atmospheres (185 lb.) and is finally used to drive additional turbine-generator sets. The capacity of the plant is stated to be 67,000 kw.

ANNOUNCEMENT has been made that the annual convention of the International Acetylene Association will be held at the Congress Hotel, Chicago, November 13, 14 and 15. It will be remembered that at last year's convention there was presented a report of the Oxy-Acetylene Committee of such length that it was necessary to print it for distribution. Since that time, the same committee has been working constantly to amplify some portions of last year's report and to assemble new material on subjects which were not covered last year. In addition to this, there have been a number of interesting developments in the field of oxy-acetylene welding and cutting, all of which will be covered in interesting detail by technical papers which are in course of preparation and will be presented at the meeting.

The program committee has made definite arrangements for a number of papers of unusual interest and it is expected that some detailed information on this subject will be available very soon; however, L. F. Loutrel, president of the association, has advised all members that suggestions for making the program more complete and more constructive will be gladly received. Headquarters of the association are at 30 East 42d St., New York City.

BETHLEHEM STEEL CO., New York, announces that on July 1 it retired from the manufacture of power house auxiliary machinery and transferred its designs and patterns to the Barnett Foundry & Machine Co., Irvington, N. J., which will look after requirements of previous customers on spare parts.

MURRAY IRON WORKS CO., Burlington, Iowa, announces the following appointments of selling agencies for its products: Isaac Hardeman, 1107 Queens Road, Charlotte, N. C.; C. Keiser & Co., 610 W. Fairview Ave., Dayton, Ohio; William Rudolph, 207 Mesnager St., Los Angeles, Calif.; P. Schmertz, 7338 Woodward Ave., Detroit, Mich.

ORDERS FOR the generating equipment to be installed in the first two stations of the Mokelumne River Development of the Pacific Gas and Electric Co. have been given to the Westinghouse Electric & Manufacturing Co. of East Pittsburgh, Pa. These orders, for approximately $400,000, include an 11,000-kv-a., 10,000-v., 300-r.p.m. vertical water-wheel generator for the Salt Springs Station and two 30,000-kv-a., 11,000-v., 225-r.p.m. horizontal water-wheel generators for the Tiger Creek Plant. The generators are to be fabricated from structural steel by arc welding and they will embody all the latest developments in water-wheel generator design.

WESTERN UNITED GAS & ELECTRIC CO. has completed interconnection with the new 132,000-v. transmission line of the Public Service Co. of Northern Illinois, extending 24.4 mi. to Electric Junction, east of Aurora. This work has been watched with interest for several months, as it completes the network of outer belt lines of 132,000 v. forming the gigantic power pool in the greater Chicago district.

HOWARD SMITH, division manager for the Iowa Public Service Co. at Cherokee, Iowa, the past two years, will succeed Ralph H. Garrison as manager of the Waterloo division, it was announced recently. Mr. Garrison resigned October 1 to join the Utilities Power & Light Corp. in Chicago. Mr. Smith was general superintendent of the Citizens Gas & Electric Co. in Waterloo, from 1912 to 1917.

MISSOURI POWER & LIGHT CO., which recently purchased the LaGrange, Mo., Municipal Plant for $60,000, paying $30,000 in cash and $30,000 in street lighting service, has formally taken over the system.

PLANT No. 8 of the Illinois Public Service Co. in Joliet, Ill., suffered several thousand dollars' fire loss September 25, when one section of the building was swept by flames and several water wheels, a generator and other electrical equipment damaged. Interruption of service was of brief duration and affected only a small section of the city.

DOCTOR BERNARD HAGUE, principal lecturer in electrical engineering at the University of Glasgow, Scotland, has accepted the invitation of the Polytechnic Institute of Brooklyn to serve as visiting professor of electrical engineering at Polytechnic for the present academic year. Dr. Hague, who has degrees from the Universities of London and Glasgow, is the holder of the Siemens Medal for Electrical Engineering and the Henrici Medal for Mathematics as well as the Diploma of the Imperial College of Science for post-graduate research. He is a member of the Institution of Electrical Engineers, the author of several standard works on electrical theory and measurements and a recognized authority in this field. He will have charge at Brooklyn Polytechnic of the conduct of graduate study and research in electrical engineering in the new plan now being developed at that institution for the benefit of technical graduates in the metropolitan district who desire to earn advanced engineering degrees by evening study.

# Books and Catalogs

ELEMENTS OF PRACTICAL MECHANICS, BY CHARLES RONALD MACINNES; First Edition, 132 pages, illustrated, 6 by 9 in., cloth, $2.25, D. Van Nostrand Co., Inc., New York, 1929.

Intended for use in engineering classes, it presupposes a knowledge of the calculus. Development of graphical methods parallel to analytical discussion and copious employment of illustrative material characterize this interesting presentation. Many problems, with answers, collected during the last 15 yr., are included. Labor in working the problems is kept down to a minimum by giving the student an opportunity to see the principles which are involved rather than to become lost in details. This is particularly true in the truss problems and in those on moments of inertia of areas.

PLUMBING QUESTIONS AND ANSWERS, BY JOSEPH E. TAGGART; Third Edition, revised, enlarged and entirely reset, 160 pages, illustrated, 4¾ by 7 in., flexible cloth, $2.00; Scientific Book Corporation, New York, 1928.

Arranged in four sections: First, plumbing rules based on New York code, presented in question and answer form with sketches; second, tests for anti-siphon traps, installation of water supply and laws governing its use; third, the standpipe and fire-line rules of 1928; and fourth, an appendix of useful tables, measures and calculations.

MODERN FEEDWATER REGULATION with the Copes system of boiler feed control, is discussed in a 16-page, well-illustrated bulletin just issued by Northern Equipment Co., Erie, Pa. This contains a complete description of Copes feedwater regulators for both low and high pressure service and includes for the first time a discussion of the Type RG combined feed-flow-water-pressure regulator. Type SS valve, type DS pump governor and the condensate drainage control, as well as the Copes valve movement indicator, are all described in detail. Many half-tone illustrations and line drawings show actual application of this equipment.

THERMO-COUPLE AMMETERS and Milliammeters for use on direct current and on alternating current of any frequency, including radio frequency, are described in a new bulletin, No. 810 by the Roller-Smith Co., 233 Broadway, New York City. These instruments incorporate a new and improved form of thermo-couple designed for high over-load capacity and sustained accuracy over a wide range of temperature.

LISTS OF OIL ENGINES of various makes and sizes available in various localities, together with oil engine generators, exciters and other accessories, are given in bulletin No. 388 just issued by Walter A. Zelnicker Supply Co., 511 Locust St., St. Louis, Mo.

ERIE CITY 3-DRUM BOILER, designed for high efficiency, quick response to load change, wide range of operation and dry steam, is described and illustrated in detail in a recent bulletin by Erie City Iron Works, Erie, Pa. Characteristics of the design to give the above results are discussed in detail and the bulletin shows many cross sections and photographs and installations of this boiler. The company is also issuing a bulletin describing the Erie City Economic Boiler, a self-contained semi-portable return tubular boiler.

FOSTER ENGINEERING SPECIALTIES are described in Catalog No. 60, a 100-page book recently issued by Foster Engineering Co., Newark, N. J. This describes the complete line of products made by this company including pressure regulators, pressure reducing valves, relief valves, pump governors, stop and check valves and many other types; these are shown in detail by cross-section drawings accompanied by descriptions of the valves and discussion of their operation. Tables of dimensions, pressure ranges and the like are given, together with prices of valves and various parts. Charts for determining steam flow, tables of capacities of regulators and valves and many other engineering data are included in the bulletin.

"WEST TEXAS, THE LAND OF OPPORTUNITY" is the name of a booklet being distributed through the industrial department of the West Texas Utilities Co., Abilene, Texas, for the purpose of showing the part that power has played in the agricultural and industrial development of that section of the country.

QUINN OIL BURNING EQUIPMENT manufactured by Combustion Engineering Corp., New York, N. Y., as made in five sizes with ratings from 10 to 150 gal. per hr., is illustrated and described in a new catalog. Oil regulating cocks and oil pressure regulating valves are also illustrated and described. Copies are available to those interested upon request.

# Power Plant Construction News

**Ark., Mulberry**—The Water Works and Improvement District, No. 1, Mulberry, plans installation of pumping machinery and auxiliary equipment, and filtration plant, in connection with waterworks and sewage expansion, entire project reported to cost more than $75,000. Dickinson & White, Rector Building, Little Rock, Ark., are engineers.

**Calif., Los Angeles**—The Fokker Aircraft Co., Glendale, W. Va., plans installation of power equipment in proposed airplane manufacturing plant at Alhambra, near Los Angeles, where tract of 30 acres of land has been acquired, entire project to cost about $250,000.

**Fla., Hollywood**—The Hollywood Ice & Cold Storage Co., will make extensions and improvements in plant for increased capacity, reported to cost more than $30,000, with equipment. O. J. Morris is president.

**Ill., East St. Louis**—The Evans-Wallower Lead Co., Montsanto Street, St. Louis, Mo., plans installation of power equipment in proposed electrolytic plant at East St. Louis, reported to cost more than $200,000.

**Ill., Riverside**—The Common Council is completing plans and will soon take bids for a municipal pumping plant, with deep-well pumping machinery and auxiliary equipment, reported to cost more than $80,000. Marr, Green & Co., 400 North Michigan Avenue, Chicago, are engineers.

**Ind., Bloomington**—The Board of Trustees, Indiana University, is said to be planning early rebuilding of portion of power plant, on the campus, destroyed by fire Sept. 24, with loss reported at close to $25,000. Dr. William Lowe Bryant is president.

**Ind., Indianapolis**—The Sterling Laundry Co., 735 Lexington Avenue, Indianapolis, has filed plans for the construction of a one-story power house to cost close to $25,000, with equipment. J. Edwin Kopf & Deery, Indiana Pythian Building, are architects and engineers.

**Iowa, Ottumwa**—The Iowa Southern Utilities Co., Centerville, Iowa, has approved plans and will proceed with construction of new addition to steam-operated electric generating station at Ottumwa, reported to cost more than $200,000, with equipment. Brown & Cook, 108 North Market Street, Ottumwa, are engineers.

**Md., Baltimore**—The Tide Water Oil Sales Corporation, Court Square Building, Baltimore, a subsidiary of the Tide Water Oil Corporation, 11 Broadway, New York, plans installation of power and pumping equipment in proposed oil storage and distributing plant at Wagners Point, Baltimore, entire project to cost $180,000.

**Mass., Woburn**—The Edison Electric Illuminating Co., Boston, has approved plans for construction of new one and two-story power substation at Lake Avenue and Cove Street, Woburn, 48 x 160 ft., reported to cost close to $100,000, with equipment. The Whidden Beekman Engineering Co., 100 Arlington Street, Boston, is engineer.

**Minn., Duluth**—The City Council is said to have plans nearing completion for the construction of a multi-story steam power plant at Commerce Street and Third Avenue, West, for central heating service, reported to cost close to $1,000,000. Work will be placed in progress at an early date. W. J. Sullivan, Palladio Building, Duluth, is architect.

**Minn., Duluth**—The Minnesota Steel Co., Duluth, a subsidiary of the United States Steel Corporation, New York, will install power equipment in proposed addition to local steel mill, entire project to cost more than $100,000.

**Mo., Galt**—The City Council has approved plans for a municipal electric light and power plant to cost about $30,000, with equipment. The Rollins Engineering Co., Railway Exchange Building, Kansas City, Mo., is engineer.

**Mo., St. Louis**—The Mallinckrodt Chemical Works, Inc., Second Street, has filed plans for extensions and improvements in boiler plant, reported to cost about $30,000, with equipment.

**N. Y., Niagara Falls**—The Union Carbide Co., Buffalo Avenue, plans installation of power equipment in proposed new addition to plant to cost about $80,000.

**N. J., Paterson**—The United Piece Dye Works, Inc., Van Houten Street, plans installation of power equipment in connection with proposed rebuilding of portion of mill, destroyed by fire Sept. 25, with loss reported at close to $60,000.

**Ohio, Bluffton**—The National Lime & Stone Co., Bluffton, plans installation of power equipment in connection with proposed rebuilding of local plant, recently destroyed by fire, with total loss reported in excess of $200,000. Frank McElroy is superintendent.

**Ohio, Cincinnati**—The Board of Trustees, University of Cincinnati, Herman Schneider, president, is reported planning an addition to power plant on the campus, estimated to cost about $80,000.

**Ohio, Cincinnati**—The Western Paper Goods Co., 1224 West Eighth Street, plans installation of power equipment in a proposed plant unit to cost about $250,000. F. H. Herold is president.

**Ohio, Cleveland**—The Hupp Motor Car Corporation, St. Clair Avenue, has filed plans for the construction of a one-story boiler plant at local factory, reported to cost about $25,000, with equipment. Ernest McGeorge, 3030 Euclid Avenue, is architect and engineer.

**Ohio, Cleveland**—The Industrial Rayon Corporation, 9801 Walford Avenue, has filed plans for construction of new one-story boiler plant, 30 by 50 ft., reported to cost about $30,000, with equipment.

**Ohio, Crooksville**—The Crooksville China Co. plans installation of power equipment in proposed new addition, entire project reported to cost more than $80,000.

**Ore., Hood River**—The Hood River Canning Co., Hood River, plans installation of power equipment in connection with proposed rebuilding of plant, recently destroyed by fire, with loss reported at $200,000.

**Ore., Marshfield**—The Mountain States Power Co., Tacoma, Wash., has plans for the immediate construction of a new steam-operated electric power plant at Marshfield, to be equipped for a capacity of 10,000-kw. Project will include a 100,000-volt transmission line from Marshfield to Dixonville, with entire development to cost close to $1,000,000. The Byllesby Engineering & Management Corporation, 231 South La Salle Street. Chicago, Ill., operates this property.

**Pa., Lancaster**—The Standard Oil Co. of Pennsylvania, Inc., Sixth and Chestnut Streets, Philadelphia, plans installation of pumping and power equipment in proposed oil storage and distributing plant on the Harrisburg Pike, Lancaster, entire project to cost about $145,000.

**Pa., Philadelphia**—F. G. Vogt & Sons, Inc., Thirtieth and Race Streets, plans installation of power equipment, in proposed three and four-story meat packing plant on Thirty-sixth Street, including refrigerating plant, entire project to cost more than $800,000. Bids will soon be asked on general contract. C. B. Comstock, 110 West Fortieth Street, New York, is engineer.

**Texas, Houston**—The Davison Chemical Co., Baltimore, Md., plans installation of power equipment in proposed new plant on 15-acre tract of land, recently acquired at Houston, entire project to cost $800,000; a boiler house is projected.

**Texas, Mercedes**—R. W. Alford, 120 West Craig Street, San Antonio, Texas, is at the head of a project to construct and operate an ice-manufacturing and cold storage plant at Mercedes, with capacity of about 50 tons per day to cost about $80,000

**Utah, Salt Lake City**—The Utah Oil Refining Co., Salt Lake City, plans installation of power equipment in proposed addition to oil refining plant, entire project reported to cost more than $300,000. J. C. Howard is president.

**Wash., Stevenson**—The City Council is said to be projecting plans for a municipal power plant and waterworks, to cost about $35,000. The Miller Engineering Co., Burke Building, Seattle, Wash., is engineer.

**Wis., Delafield**—The Milwaukee Electric Railway & Light Co., Milwaukee, has plans under way for construction of one-story addition to power plant at Delafield, reported to cost close to $40,000, with equipment. F. A. Luber is company engineer.

**Tenn., Chattanooga**—The Davenport Hosiery Mills, Inc., plan installation of power equipment in connection with proposed new addition, reported to cost close to $100,000.

**Va., Newport News**—The Horace E. Dodge Boat & Plane Corporation, 511 Fifth Avenue, New York, J. Gilmore Fletcher, vice-president, will install power equipment in proposed motor boat and flying boat manufacturing plant, entire project to cost more than $600,000; a boiler plant is projected.